JUN 8 1925

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See Advertisement, page 53, May 15. 2584

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ENGINE, cylinders 18 in. dia. by 24 in. stroke, flywheel 9 ft. 6 in. by 21 in. face, speed 180 r.p.m., 150/180 B.HP.
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See Advertisement page 58, May 15. 2402

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Belt flywheels 16 ft. diameter by 26 in. wide. Corliss valves to inlet and exhaust of both cylinders. Vertical Air Pump and Condenser below floor level, worked by L crank from L.P. crosshead.
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Draughtsmen, before Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Milligate Building, Manchester. 2863

TENDERS.

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for :—

1. BUFFER WASHERS and DIVISION PLATES.
2. INDIA-RUBBER SPRINGS for Buffers, etc.

Tenders due on the 5th June, 1925.
Tender Forms obtainable from above. J 111

THE GONDAL RAILWAY, INDIA, are prepared to receive

Tenders for the Supply of :— CARRIAGE UNDERFRAMES with STEEL BODIES and BOGIES.

Specifications, Forms of Tender and Drawings may be obtained, on application, at the Offices of ROBERT WHITE & PARTNERS, Consulting Engineers, 3, Victoria Street, S.W.1, with whom the Tenders are to be lodged by Twelve Noon, on June 22nd, the envelopes being marked "Tender for Steel Coaches."

A fee of Three Guineas will be made for each copy of the Specification, which fee will be returned in the event of a *bona fide* Tender being lodged. J 110

COUNTY OF LONDON.

REPAIRS TO PAVEMENT OF CARRIAGEWAYS OF BLACKWALL AND ROTHERHITHE TUNNELS.

The London County Council invites

Tenders for Repairs to the GRANITE SETT PAVEMENTS and GRANITE CHANNELLING of Blackwall and Rotherhithe tunnels.

The Specification, Form of Tender, Drawings, etc., may be obtained on application to the Chief Engineer of the Council at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £3. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 8th June, 1925, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX, J 82
Clerk of the London County Council.

WEST RIDING COUNTY COUNCIL.

TENDERS FOR PLANT—CALVERLEY AND HORSFORTH NEW ROAD AND BRIDGES.

The County Council of the West Riding of Yorkshire are prepared to receive

Tenders for the Supply and DELIVERY of the following PLANT, etc., required in connection with the above works:

One Petrol Tractor.
Four Brake Wagons.
18 Tip Wagons.
2000 lin. yards Railway Track.
20 Switches.

Forms of Tender and further particulars can be obtained at the Office of the West Riding Surveyor, County Hall, Wakefield.

Tenders are to be addressed to the Clerk of the West Riding County Council, County Hall, Wakefield, and delivered not later than Ten a.m., on Wednesday, the 3rd day of June, 1925, endorsed "Tender for Plant, etc."

The County Council do not bind themselves to accept the lowest or any Tender.

Office of the Clerk of the County Council, County Hall, Wakefield. J 98

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

1500 STEEL TYRES.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 18th May, 1925.

A fee of 20s. will be charged for the Specification, which is not returnable. Tenders must be submitted not later than Noon, on Thursday, 28th May, 1925.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board,
R. C. VOLKERS,
Secretary. J 87

COUNTY BOROUGH OF STOKE-ON-TRENT.

LOW TENSION SWITCHGEAR: CONTRACT NO. 2513.

Tenders are Invited for the SUPPLY of LOW TENSION SWITCHGEAR.

Specification and Tender Form may be obtained from the Borough Electrical Engineer, St. George's Chambers, Wolfe Street, Stoke-on-Trent, upon payment of deposit of £2, which will be returned upon receipt of a *bona fide* Tender, which must be delivered to the Undersigned not later than Tuesday, 9th June, 1925.

E. B. SHARPLEY,
Town Clerk.

Town Hall,
Stoke-on-Trent.
18th May, 1925. J 100

COUNTY BOROUGH OF SOUTHAMPTON.

RECONSTRUCTION OF COBDEN BRIDGE IN REINFORCED CONCRETE.

Tenders are Invited for the RECONSTRUCTION of the above mentioned BRIDGE having five spans of about 75 ft. each including the provision of a temporary bridge, approaches and all incidental works.

Drawings of the proposed works can be seen at the office of the Engineer for the work, Mr. H. W. FITZSIMONS, B.Sc., M.Inst.C.E., 39, Victoria Street, Westminster. Copies of the Specification, Bill of Quantities and Form of Tender are to be obtained from the Engineer's Office on payment of Five Pounds, which will be returned on receipt of a *bona fide* Tender and return of all documents.

Sealed Tenders, endorsed "Cobden Bridge, Concrete," must be sent to the Town Clerk, Southampton, not later than Ten o'clock in the forenoon on Monday, the 15th day of June, 1925.

The Corporation do not undertake to accept either the lowest or any Tender.

R. R. LINTHORNE,
Town Clerk.
18th May, 1925. J 97

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

(A) STEEL BOILER TUBES.
(B) FIVE SUPERHEATED BOGIE MAIL ENGINES and TENDERS, 4-6-0 type.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 21st May, 1925.

A fee of 20s. will be charged for each Specification, which is NOT returnable.

Tenders must be submitted not later than Noon, on Wednesday, 3rd June, 1925.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the orders.

By Order of the Board,
R. C. VOLKERS,
Secretary. J 113

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Borough Council invites

Tenders for the Supply of :—

(A) One WATER TUBE BOILER, capable of supplying 45,000 lbs. of steam per hour. Fitted with mechanical stoker, feed pump, fans, piping, conveyors, etc.

(B) Two 30-inch "CENTRIFUGAL" PUMPS. Strainers, Valves and Pipework.

Specifications, Forms of Tender, and other particulars may be obtained from Mr. F. HILL, Engineer and Manager, Electricity Works, 85, Fulham Palace Road, W.6.

Sealed Tenders, endorsed "TENDER FOR BOILER and/or PUMPS," must be delivered to the undersigned, at the Town Hall, Hammersmith, W.6, not later than Eleven a.m., on FRIDAY, 12th JUNE, 1925.

The Council does not bind itself to accept the lowest or any Tender.

HUGH ROYLE,
Town Clerk.
Town Hall, Hammersmith, W.6.
18th May, 1925. J 106

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C.2, invite

Tenders for :—

		s.	d.
1.	Sheffield Tools, etc. .....Fee	7	6
2.	Plate Glass, etc. ..... ,,	2	6
3.	Drawn or Extruded Brass Strips, Angles, etc. ..... ,,	5	0
4.	Canvas, etc. ..... ,,	10	0
5.	Spare Parts of Carriages and Wagons (Buffers) ..... ,,	20	0
6.	Spare parts of Carriages and Wagons (Axleguards, etc.) ..... ,,	7	6
7.	Spare Parts of Locomotive Engines ,,	10	0
8.	Steel Drawbars, etc., for Wagons ..... ,,	5	0

Tenders are due by Eleven a.m., on 9th June, 1925.
Tender Forms obtainable at above address. Fees not returnable. J 115

APPOINTMENTS OPEN.

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.

Principal: CHARLES COLES, B.Sc. (Lond.).

The Services will be Required in September next, of TWO Full-time ASSISTANT LECTURERS in Engineering, qualified in each case to teach up to Honours B.Sc. standard. The main subjects required will be those of Mechanical and Civil Engineering, but a good knowledge of Electrical Engineering will be a recommendation.

SALARY SCALE: £300—15—450 per annum, with such variation in the scale as may be necessary by the application to Cardiff of the Burnham Award.

Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three recent testimonials, should reach the Principal (from whom further particulars may be obtained) on or before Saturday, 30th May.

The successful candidates will be required to pass a Medical Examination by the Authority's Medical Examiner for Teachers, at Cardiff, before commencing duties, and to contribute under the Local Pensions Scheme, if not accepted under the School Teachers (Superannuation) Acts.

JOHN J. JACKSON,
Director of Education,
City Hall, Cardiff. J 22

CITY OF LEICESTER EDUCATION COMMITTEE.

LEICESTER COLLEGE OF TECHNOLOGY.

Principal:
G. F. O'RIORDAN, B.Sc., M.I.Mech.E., M.I.A.E.

Applications are Invited for the POST of HEAD OF THE DEPARTMENT of MECHANICAL ENGINEERING, which will become vacant on 1st September next.

Applicants must have had both Works and Teaching experience. They should submit evidence of initiative and organising ability.

Salary according to the Burnham Scale for Graduates, plus an additional sum of £47 10s. per annum.

Forms of application, together with particulars of the appointment, may be obtained from the Registrar to whom they must be returned not later than Saturday, 6th June, 1925.

F. P. ARMITAGE, M.A.,
Director of Education. J 86

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

TWO TEMPORARY ASSISTANT ENGINEERS.

The Directors are prepared to receive

Applications (by letter only) for APPOINTMENT to the above POSTS on the Company's Railway in India.

Candidates should be between 24 and 28 years of age, and must have had a good general and technical education and have obtained a degree at a recognised Engineering College or have passed the Associated Membership Examination of the Institution of Civil Engineers. In addition, they must possess at least one year's practical experience with a railway company or on public works.

SALARY: Rs. 450 and upwards per calendar month, according to age.

TERMS: A three years' agreement in the first instance, first-class free passage to India and home again on satisfactory termination of services.

The selected candidates will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Applications, giving full details of candidate's career, in chronological order (with dates), together with copies only of testimonials, etc., must be addressed to the undersigned not later than the 5th June, 1925.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France, Westminster, S.W.1.
15th May, 1925. J 89

Managing Director Wanted, capable of taking charge of large and important manufacturing works near London, with experience of internal combustion engines.—Write, stating experience and qualifications, to CLIFFORD TURNER & HOPTON, Solicitors, 81, Gresham St., E.C. J 84

Required for Chile, Railway ENGINEER, age 25-30; thorough knowledge of Permanent Way, bridges, culverts, etc. Commencing salary £400 p.a. ALSO CHIEF DRAUGHTSMAN for Way and Works department; knowledge ordinary survey work. Age 30-35. Commencing salary £300 p.a. Three years' agreement in each case, salaries increase £50 annually. Furnished quarters, water, fuel and light free. Working knowledge Spanish essential.—Applications with certificates (copies) from Railway employers, to SELLEN'S Appointments Bureau, 29, Paternoster Row, E.C.4. J 121

Applications are Invited for the POST of JUNIOR TECHNICAL OFFICER to assist in the development of designs at H.M.S. "VERNON," Portsmouth.

Salary £175, rising by annual increments of £15 to £235, plus full Civil Service Bonus. Present commencing salary including bonus, £278 18s. 0d. The bonus varies according to the Official cost of living figures.

The duties of the post are concerned primarily with the design of small electrical and acoustical apparatus, and a sound knowledge both of mechanical and electrical design is essential. A good grounding in Electrotechnics is required, but a University degree is of secondary importance.

Preference will be given to Ex-Service men.

Applications, accompanied by a statement of qualifications, should be forwarded to the SECRETARY OF THE ADMIRALTY (C.E. Branch), London, S.W.1, not later than the 8th June. J 114

Wanted, for a Works in the Provinces, GENTLEMAN thoroughly versed technically and theoretically in heat transfer problems in connection with condensers and heaters for power plants, etc. Must be a man of good education. Please supply all particulars as to experience, age and salary.—Address, J 107, Offices of ENGINEERING.

Experienced Sales-Manager (35-40 years), REQUIRED to take charge of London office; must be thoroughly qualified mechanical engineer with knowledge of electrical machinery; integrity energy method and enterprise essential qualifications. Excellent prospects for right man. Only those with all these qualifications need apply. Applicants will please send full particulars as to age, education and technical and commercial experience.—Address, J 126, Offices of ENGINEERING.

General Manager with First- class commercial experience REQUIRED for large machine tool works in Yorkshire district. Applications will be treated in strictest confidence. Give full particulars of experience, salary expected and copies of three testimonials.—Address, J 78, Offices of ENGINEERING.

A Well-known Firm of Safe and Strong Room Manufacturers REQUIRE an ASSISTANT to their WORKS MANAGER for London. Must be fully competent, young and energetic, with good experience in D.O. and works. Good opening for suitable man.—Address, giving full particulars of experience, age, and salary required, J 102, Offices of ENGINEERING.

EGYPTIAN STATE RAILWAYS, TELEGRAPHS AND TELEPHONES.

Applications for the following APPOINTMENTS are REQUIRED and should be addressed to:—
THE GENERAL MANAGER,
c/o The Inspecting Engineer (Egyptian Govt.),
Queen Anne's Chambers,
Westminster, S.W.,
not later than June 10th, 1925.

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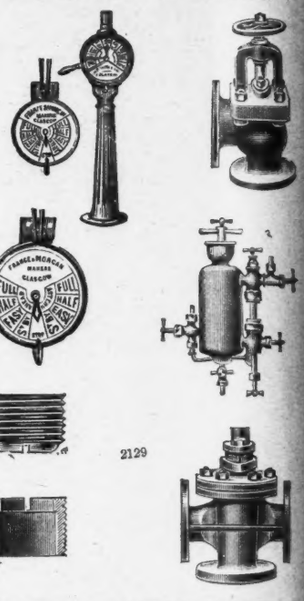

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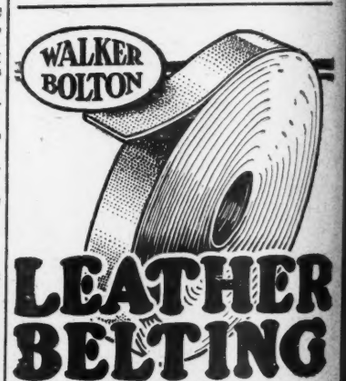

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THE MOTION OF ELECTRICITY IN METALS.

On May 6 last, at the Institution of Mechanical Engineers, Dr. H. A. Lorentz, the famous Haarlem physicist, delivered the May lecture of the Institute of Metals. He took as his subject "The Motion of Electricity in Metals."

He said that physicists in picturing an electric current had always tended to consider it as comparable to something material, such as the flow of water through a tube. Maxwell, it was true, whilst recognising the convenience of the analogy, observed that we had no evidence that the electric current was really a current of a material substance, but other physicists either less cautious than Maxwell, or more anxious to understand what was really happening inside a conductor, had not shrank from developing a truly material theory. According to their view, a metal contained in the interstices between its atoms one or two electric fluids, which, under the action of an electromotive force, were supposed to move forward against a resistance analogous to the wall friction of a water pipe. In the two-fluid form of the theory the atoms were regarded as small neutral particles, whilst in the one-fluid theory one of the electricities was supposed to be fixed to the atoms, giving them a definite charge.

To-day no physicist doubted that each atom consisted of a positively-charged nucleus surrounded by a guard of electrons, the number of which was equal to the atomic number of the element, being 29 for copper, 26 for iron and 47 for silver. These numbers represented also the net positive charge on the nucleus. Nearly the whole mass of a body was concentrated in these nuclei, which, in the solid state, occupied definite positions, the arrangement being perfectly regular over ranges much greater than the molecular distances. Indeed, Dr. Rosenhain had that morning shown him a single crystal of aluminium in the shape of a long rod measuring about one square centimetre in section. In most cases, however, the crystals in metals were very minute, but each, nevertheless, contained millions and millions of atoms. The nuclei of these atoms formed the rigid framework of the metal, and hence a current must consist wholly of the negative electrons.

According to Bohr's theory, the electrons of an atom were rotating round its nucleus at speeds which might be comparable with that of light. A model in which the electrons were static had also been proposed and had certain advantages from the chemical standpoint, but Bohr's theory had had such a wonderful success in interpreting the lines of the spectrum that he thought it might safely be trusted to, although the theory of the motion had only been worked out completely in the case of the hydrogen atom with its single electron. As was well known, in astronomy the problem of the mutual gravitation of three bodies presented almost insuperable difficulties, and in the case of the heavier atoms there were not merely three, but dozens of bodies to be considered. The Bohr theory had, however, provided us even in these cases with a general picture of what was happening.

The motions internal to the atoms were, thus, so intense that the motions due to heat became, in comparison, merely a slight tremor, and the strongest electric current was probably only a comparatively unimportant additional phenomenon.

A simple relation could be found between the strength of a current and the "mean velocity" of the electrons, if we took into account all the electrons, whether free or bound. Thus we might consider the case of a copper wire of one square millimetre in section, through which a current of one ampere was flowing. The number of atoms in a cubic centimetre of copper was $8{\cdot}52 \times 10^{22}$, and as the copper atom had 29 electrons the corresponding number of electrons was $2{\cdot}47 \times 10^{24}$. The electronic charge being $1{\cdot}59 \times 10^{-20}$ electromagnetic units, the total negative charge per centimetre^3 was $3{\cdot}93 \times 10^4$. The strength of the current, measured in the same units, was 10, and hence we could work out that the mean velocity of the electrons was $2{\cdot}5 \times 10^{-4}$ cm. per second. The mean distance between the atoms was about $2{\cdot}3 \times 10^{-8}$ cm., so that if all the electrons had the mean velocity found above, each would pass by many thousands of atoms per second. On the other hand, if the circuit was 10 cm. long, it would take the electrons 11 hours to go round it at this mean velocity. If, however, the current were carried solely by free electrons forming but a small fraction of the full number the time of transit would be correspondingly reduced.

He did not wish to imply that the same electrons remained free for any considerable length of time. Whilst some were set free, it might be by collisions of the atoms with moving particles; or it might be by a kind of dissociation produced by heat, or, perhaps, by the radiation due to the transit of an atom from one to another of Bohr's stationary states; other electrons were recaptured. Hence, if we could watch an individual negative particle we should probably see it moving for a short time, and then imprisoned for a while in an atom until again set free. Though all this was very complicated, yet it was not difficult to account for Ohm's law, which followed naturally from the consideration that any current corresponded only to small changes in the states of atomic motion, and variations depending on small changes were always directly proportional to such small changes.

Messrs. Tolman and Stewart had, the lecturer continued, proved by definite experiment that the current in metallic conduction was carried by the negative electrons. The principle employed might be made clear by a hydraulic analogy. Thus, if a tube in the form of a closed ring, filled with water, were suddenly set in rotation round its geometric axes, the water would at first lag behind and only gradually acquire the speed of the tube. Conversely, if the tube were suddenly stopped, the water would continue to flow on for some time. Its speed of motion could be calculated if we knew the wall friction.

In the experiments of Tolman and Stewart the tube was represented by a wire and the water by the electrons in the wire. Any relative motion of the electrons to the wire constituted a current. The strength I of this current, due to the sudden stoppage of the motion of the conductor, could be calculated, and was given by the expression

$$I = \frac{l\,m}{r\,e}\,.\,v$$

where l denoted the length of the wire, v its original velocity of motion, and r its resistance, whilst $\frac{m}{e}$ was the mass of the carriers of the current divided by their charge. This ratio could be calculated from the above expression and proved to be identical with the value found in the case of the cathode rays. The observed direction of the current showed, moreover, that the carriers had a negative charge, and hence an electric current through a metal was really conveyed by the electrons.

In Maxwell's chapter on the "Dynamical Theory of Electromagnetism" (which would always remain remarkable for the way in which the general equations of dynamics were applied to electromagnetic phenomena) that author had shown that the energy of the magnetic field was kinetic. This kinetic energy, Maxwell pointed out, might be conceived as made up in three parts, of which T_m represented the ordinary kinetic energy due to the mass of the conductor, T_e that due to the electric currents taken by themselves, and T_{me} that due to the motion of the electricity relatively to the conductor. It was this third component which had been measured by Tolman and Stewart. Maxwell had himself tried to detect this effect, but his instruments were not sufficiently sensitive.

Since the current was now proved to be carried by these electrons, it followed that the self-induction of a circuit calculated in the ordinary way required a small correction. It would, in fact, be increased by the amount $\frac{l\,m}{N\,\omega\,e^2}$, where N denoted the total number of electrons in unit volume and ω the cross-section of the conductor, the other terms having the same significance as before.

In 1880, Hertz had tried to detect this term, but could only find an upper limit. From Hertz's data, the lecturer had been able to calculate that in his copper wire the number of free electrons per cm^3. must have been more than $2{\cdot}2 \times 10^{19}$. This calculation, he added, had been rendered difficult by Hertz's use of arbitrary electric units, the present international standards being not then in general use.

Twenty-five years ago Drude had founded a theory of metallic conduction for heat and electricity on the hypothesis that the free electrons had their share in the thermal agitation, and that the mean translational kinetic energy acquired by each was the same as that of an ordinary molecule at the same absolute temperature, which was equal to $\frac{3\,k}{2}\,T$, where k was Boltzmann's constant.

In deducing Drude's result it was unnecessary to make any special assumption as to the mutual action of an electron and of an atom near which it came.

Suppose that at a certain instant of time there were N free electrons with a mean velocity w. Their encounters with the atoms would tend to reduce this velocity by an amount of, say, dw in the time dt. Then, since the progressive motion w constituted only a slight departure from the natural state, it was justifiable to assume that the decrement dw was directly proportional to w, and it was also proportional to dt. We could thus form the equation $dw = a\,w\,dt$, where a was some coefficient. Integrating this expression we got

$$w = w_0 e^{-at}$$

where w_0 represented the velocity at the time $t = 0$. This velocity w_0 might be regarded as acquired through the action of an electric force E acting throughout an infinite time prior to the time $t = 0$. If unimpeded, such a force would in unit time give an electron the velocity $\frac{e\,E}{m}$. Actually, it only acted unimpeded by encounters for a very small time $d\tau$, say, and thus the velocity acquired at some time τ anterior to $t = 0$ was $\frac{e\,E}{m}\,d\tau$. Of this velocity the amount remaining at the time $t = 0$ would (from the formula just found for w) be

$$\frac{e\,E}{m}\,.\,d\tau\,.\,e^{-a\tau}$$

Hence, the average velocity at the time t_0 would be

$$w_0 = \frac{e\,E}{m}\int_0^\infty t^{-a\tau}\,d\tau = \frac{e\,E}{a\,m}$$

The current carried would therefore be $N\,e\,.\,\times\,.\,\frac{e\,E}{a\,m}$ and the coefficient of conductivity was accordingly given by

$$\sigma = \frac{N\,e^2}{a\,m}$$

To determine the value of a it might be noted that the velocity of an electron at any instant was what it would acquire during the average interval between successive encounters with atoms. This average time was $\frac{2\,l}{u}$ where l denoted the "mean free path" of the electron, and u the properly chosen mean velocity due to the heat motion. We thus got

$$w_0 = \frac{E\,e}{m}\,.\,\frac{2\,l}{u} = \frac{E\,e}{m\,a}$$

so that $\frac{1}{a} = \frac{2\,l}{u}$ and Drude's expression became

$$\sigma = \frac{N\,e^2\,l}{2\,m\,u}$$

Drude had made a further step by assuming that the conduction of heat was due to kinetic energy carried by the electrons from a place of higher to one of lower temperature. On this assumption he found that the coefficient of thermal conductivity κ depended on l and N in the same was as did the electrical conductivity σ. Hence these terms disappeared from the ratio, which he found to be given by the expression

$$\frac{\kappa}{\sigma} = 3\left(\frac{k}{e}\right)^2 T$$

where as before $\frac{3\,k\,T}{2}$ denoted the average kinetic energy of the atom of a monatomic gas at the absolute temperature T. The value of k was known to be about $1{\cdot}37 \times 10^{-16}$, whilst e was

$1 \cdot 59 \times 10^{-19}$. Substituting these values, and taking T as equivalent to 18 deg. C., we got

$$\frac{k}{\sigma} = 648 \times 10^8$$

The observed value for silver was 686×10^8.

This comparison indicated that there must be a good deal of truth in Drude's hypothesis, which, however, failed to account for the observed specific heat of metals, which at ordinary temperatures agreed with the view that the atoms has 6 deg. of freedom. On Drude's theory each electron would absorb heat corresponding to these degrees of freedom, and the specific heat of copper, for example, should thus be about 15 times the observed value if all the electrons were free, whilst if, on the other hand, only a small fraction were assumed to be free, the free path as then calculated became impossibly great.

It was necessary, therefore, to abandon the attempt to define a in terms of the actual free path, but we might as an alternative take l as implying not the mean distance travelled between successive encounters, but as the distance in which a mean velocity would fall to $\frac{1}{e^2}$ of its original value. This change would not affect Drude's formula for the ratio of the two conductivities. Modification would, however, perhaps be required at very low temperatures where even in the case of atoms the theory of equi-partition of energy failed to hold good.

In conclusion, Professor Lorentz next discussed the experiments of Kamerlingh Omnes, which showed that several metals completely, or almost completely, lost their resistance when cooled below a certain temperature, which was 4·2 deg. absolute in the case of mercury, 3 deg. absolute for tin, and 7·3 deg. absolute for lead. Below these temperatures currents could persist in these metals for hours or days, and they might be regarded as perfect conductors. In his latest experiments Professor Omnes had obtained results which indicated that even in this super-conductive condition the electrons were not wholly free. It seemed as if there were definite paths along which, only, could they move without encountering resistance, but that they could not freely move sideways. In the experiments in question a magnetic field was established across one diameter of a sphere of the metal under test. This was done at ordinary temperatures with the result that the transient current produced at the outset was quickly destroyed by the resistance, but the magnetic field remained. The sphere was then cooled to bring it into the super-conductive condition, and whilst in this state a second and additional magnetic field was established, the direction of which made an angle with that of the original field. The currents induced by this new field persisted, since the metal was super-conductive and theory showed that had the electrons been free these currents should have experienced a motion of precession about the axis of the original magnetic field. No such phenomenon was, however, detectable. This might be accounted for as above suggested, but it was very evident that super-conductivity was well worth further close and careful examination.

THE PHYSICS OF RUBBER TYRE MANUFACTURE.

THE predominant position that physics now occupies in technical science is due to recognition of the fact that physical conditions, such as the state of aggregation, surface development, size of particles, temperature, pressure, &c., are at least as important factors in many reactions and durability problems as is the chemical composition. The physics of rubber were studied before chemists began to understand the material, but the chemistry of rubber might now be regarded as cleared up to a certain extent, if it were not that chemistry so far fails to account for the characteristic properties of rubber. The wise rubber manufacturer has therefore added physicists to his research staff of chemists, and they find plenty of problems to attack and much matter for co-operative effort and for discussion. In his lecture on "Physics in the Rubber Industry, with Special Reference to Tyre Manufacture," delivered on April 29—the eighth Institute of Physics lecture on Physics in Industry—Dr. Walter Makower was severely practical and addressed himself more to the business man than to the physicist and limited himself to the tyre problems which had confronted him in the works of the Dunlop Rubber Company.

The raw rubber which the manufacturer receives varies much with the origin, such conditions as soil, climate, age of the tree, method of coagulation adopted, transport conditions, affecting it considerably. Much has been done to secure greater uniformity; but progress in that direction is slow. The variability of the raw material would not much matter, Dr. Makower remarked, if the manufacturer could rely on suitable tests. Until recently, however, rubber had largely been graded by colour. For smooth working in the factory, hardness was one of the most important qualities. When the rubber was too hard, great difficulties were experienced in extruding in the preparation of the tyre treads, solid tyres or inner tubes, and in topping or frictioning rubber on the cotton fabrics forming the walls of pneumatic tyres. Damage done to the fabric in these operations was fatal. When the rubber was too soft, on the other hand, the final product suffered. Hardness used to be estimated by the touch or by a biting test. What was wanted was measurement of the viscosity, and that was done in the Dunlop works by forcing the rubber at 80 deg. C., when it was relatively soft, through the orifice of a "plastometer." A cylinder containing the material was immersed in a water bath, maintenance of constant temperature being essential. When the viscosity (reciprocal of plasticity) was plotted against the time the rubber had been milled or masticated, one rubber might give three times the value of another. As the temperature of mastication was lowered from 100 deg. to 75 deg. C., the weight of rubber masticated per minute went up from 2·0 to 5·65 lb.; during the mastication the rubber should therefore be kept as cool as possible on the rolls. After mastication the rubber gradually regained some of its hardness by "maturing"—a term indicative of our ignorance of what took place. The plastometer showed that a rubber would become by maturing as hard in 30 hours at 134 deg. F. as it became in 300 hours at 60 deg. F. Rubber should evidently be stored cool to remain soft. The subsequent extruding and calendering again demanded constant temperature. The temperature used to be judged by touch or by mercury contact thermometers; thermocouplers had only been introduced into rubber works by the physicists.

The incorporation in the rubber, after milling, of the sulphur and compounding drugs was controlled by mechanical tests. Dr. Makower's stress-strain curves, in which elongation was plotted against load, showed how the rapid rise, almost to a maximum, of the elongation of a pure rubber for an inner tube was retarded and decreased by the compounding agents. The hardness, resistance to abrasion, hysteresis losses and resistance to fatigue of the final product depended as much upon the physical state, size of particles, &c., of the drug as upon its composition. Thus, two materials as similar as lamp black and gas black behaved very differently in solid tyres; but our knowledge of these matters was largely empirical. Vulcanisation (also called "curing"), *i.e.*, the reaction between the sulphur and the rubber, set in about 115 deg. C., and accelerated rapidly with rising temperature. Articles to be cured were placed in pans heated by high-pressure steam. With bulky goods like tyres there was great danger of overcuring the outside before the heat reached the inside. Very slow heating would take much time, and in this instance time was literally money. The amounts of sulphur and accelerators added were therefore adjusted to the requirements, and for that purpose the rate of the temperature penetration into the tyre and the temperature distribution had first to be determined. Within the last two years this had been accomplished with the aid of thermocouples by D. F. Cranor in America and by A. A. Perks and R. W. Griffiths, of the Dunlop Company, whose researches, on four-ply and eight-ply covers promised to revolutionise vulcanisation.

Passing to the design and balance of a tyre, Dr. Makower pointed out that the tyre consisted of a cotton casing, the plies of which were held together with rubber, surrounded by the outside rubber tread and side-walls, and the intermediate mixes which serve to attach the hard outside to the case and to protect it; there were additional structures, such as beads for holding the tyre on the rim. In service, the cotton, which was now generally applied in the form of cords, was apt to fail by fatigue under the repeated bending of the case-walls. All the parts should be made so as to fail simultaneously owing to abrasion, loss of internal adhesion, &c, but it was customary to let the tread wear away before other elements failed—a psychological rather than a physical consideration; people seemed to be ready to admit that the tread might wear through. Balance of the parts could be secured by physical tests; but the methods applied had too closely followed the analogy of metal testing. The properties of the cords had to be adjusted to their position in the ply, which was stretched on the outside and compressed on the inside. The cotton was tested at the Dunlop works in machines in which the threads were bent by passing over rollers, and had to raise and lower weights in harmonious motion; owing to the variability of the cotton, hundreds of threads had to be submitted to this fatigue test. There was no standard test for the fatigue value of the insulating rubbers, which were placed between the plies to prevent their rubbing on each other. One might build up membranes of alternate layers of cord and of the insulation, stretch the membranes over drums charged with compressed air and then tap them with a rounded tool; but a visual method would be required to indicate incipient breakdown.

The wear of the rubber depended greatly upon the conditions of service and road, the skill of the driver, the weight and steadiness of the car, &c., and the many laboratory methods of testing in use would put the tyres into almost any order of merit. Dr. Makower considered that the adjustment of the slip between the rubber and the abrading surface was the characteristic feature representing road wear; plotting rate of abrasion against slip, he found that with small slip there was very little abrasion, but that with increasing slip the abrasion grew rapidly. As regards hysteresis, it should be borne in mind that the very object of providing a tyre, for shock absorption, implied the existence of damping forces. It was futile to design car and tyre separately; careful adjustment between springs and tyres was needed, and the whole question of the function of tyre equipment had been proved to admit of mathematical treatment in a paper which A. Healey had brought before the Institution of Automobile Engineers last winter.* Hysteresis tests of the rubber and the cotton composing the tyre walls had often been made at slow speeds, whilst the actual deformations in the tyre might take place at the rate of 50 cycles per second. To satisfy road service conditions the specimen should be subjected to the impact of a heavy pendulum of adjustable mass and impact duration. The observations might be checked by inserting thermocouples into the tyre rotating on a machine; the difficulty of bringing out the leads of the rotating couples might be overcome with the aid of slip rings.

Many problems, such as the storing of goods to obviate their deterioration with age, could only be solved by co-operative effort. For preservation in hot climates some compounded materials were mixed with a small percentage of paraffin wax which, exuding out, formed a protective film. The deterioration seemed largely to be an oxidation effect, and accelerated ageing tests were now made in oxygen and ultra-violet light at 70 deg. C.; the dangerous region of the spectrum was not yet well determined.

Trouble in so complicated a production as a tyre might arise from many causes, and a failure could not always be tracked down by inquiries in the various departments of the works, or finally be

* ENGINEERING, December 12, 1924, page 805.

BOILER HOUSE; LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., ENGINEER.

FIG. 26. GRAVITY-BUCKET CONVEYOR OVER COAL BUNKERS.

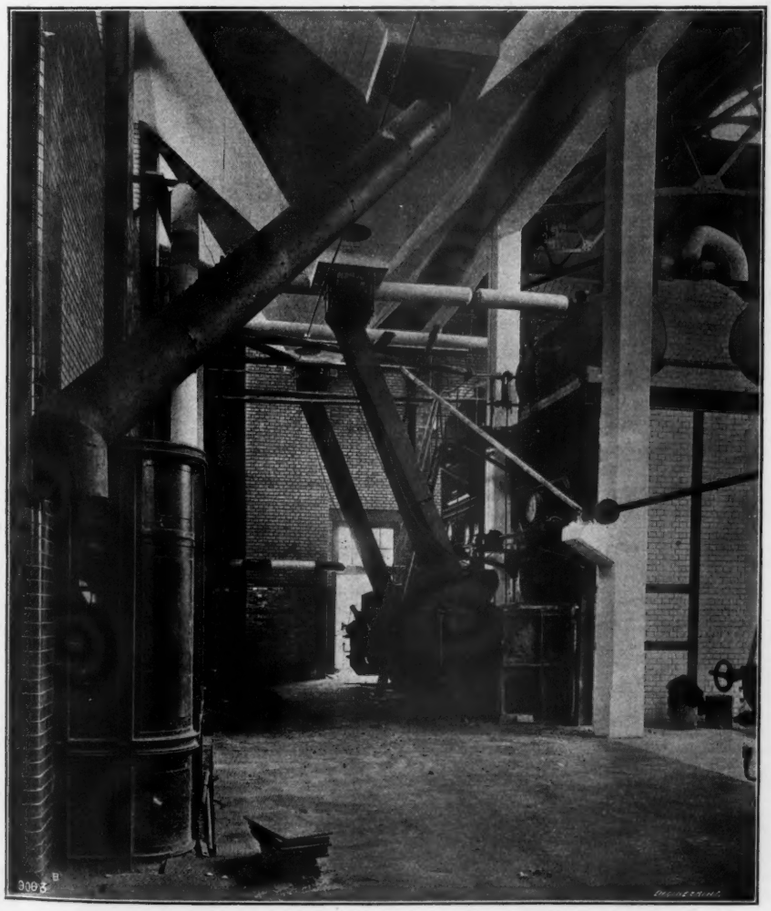


FIG. 27. INTERIOR OF BOILER ROOM.

disposed of temporarily by calling upon the physicist to devise some test. While urging harmonious co-operation of management and research staff and the appointment of a scientific man of high attainment on the board of influential corporations, Dr. Makower quite admitted that some managers had good reasons not to be impressed by the records of measurements made apparently for the sake of measuring.

THE LITTLETON RESERVOIR OF THE METROPOLITAN WATER BOARD.

(*Continued from page* 596.)

BEFORE describing the equipment of the pumping station, it may be of interest to explain the circumstances which led to the adoption of the particular type of plant which has now been installed. The service to be performed was of a nature permitting the employment of various types of plant, and as the unavoidably low load factor set an economic limit to the allowable capital expenditure, the specification issued by the Board's Chief Engineer was drafted so as to permit each manufacturer to tender for the type of plant he could offer most advantageously. The units were required to be not less than four and not more than six in number, and the overall fuel consumption per pump horse-power was required to be guaranteed under penalty.

To guide prospective tenderers, the probable average continuous pump horse-power, the estimated cost of bituminous coal, of anthracite beans, and of fuel oil, having calorific values of 11,000 B.Th.U., 13,500 B.Th.U., and 19,000 B.Th.U. per pound, respectively, were given, and the cost of buildings per cubic foot, wages rates, capital and depreciation charges, and expected life of various classes of machinery were stated in the specification; certain constants to be used in estimating the total cost of fuel were also prescribed. Thus, for example, the total coal consumption for a steam-driven plant was to be taken as 10 per cent. above the tenderer's guaranteed consumption per pump horse-power, with the addition of 0·8 ton per 24 hours. As the contract was to be awarded on the basis of the lowest annual overall charges, as calculated from the contractor's price, fuel consumption and data mentioned above, the specification attracted considerable competition, numerous tenders being received from Continental, as well as from British, manufacturers for pumps driven by Diesel engines, gas engines, steam turbines and reciprocating steam engines, and it is particularly satisfactory that, in these circumstances, the Board were able to award the contract to Messrs. Worthington-Simpson, Limited, of London and Newark. Included in the specification were drawings of two acceptable general arrangements, one for Diesel engines driving centrifugal pumps, and one for four Uniflow engines arranged *en échelon* driving similar pumps, the successful tenderer adopting the latter arrangement, as illustrated in Fig. 23, on Plate XL, published with our last issue.

The combined capacity of the four pumping sets ranges from 343,000,000 gallons per 24 hours against a head of 30 ft., to 250,000,000 gallons against a head of 46 ft., the revolutions at these heads being 125 and 140 per minute, respectively. The pump horse-power of each unit is approximately 600, or 2,400 in all, the maximum guaranteed pump efficiency being 81 per cent. and the guaranteed overall coal consumption per pump horse-power per hour, on a 24 hours trial, being 1·85 lb. of bituminous nuts with a calorific value of 11,000 B.Th.U. per pound. The steam pressure is 200 lb. per square inch and the superheat 200 deg. F.

In describing the general arrangement of the pumping station in our previous article, we referred briefly to the method of handling the coal and ashes. The coal, it will be remembered, is delivered by motor lorries and dumped into a hopper located as shown in Fig. 23, on Plate XL, published with our last issue, whence it is raised and dumped into any one of the five bunkers constructed over the firing floor of the boiler room by means of a gravity-bucket conveyor. This conveyor, which was supplied by the Hepburn Conveyor Company, of Wakefield, has a capacity of 20 tons per hour and is

BOILER-HOUSE EQUIPMENT; LITTLETON RESERVOIR PUMPING STATION.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

Fig. 28.

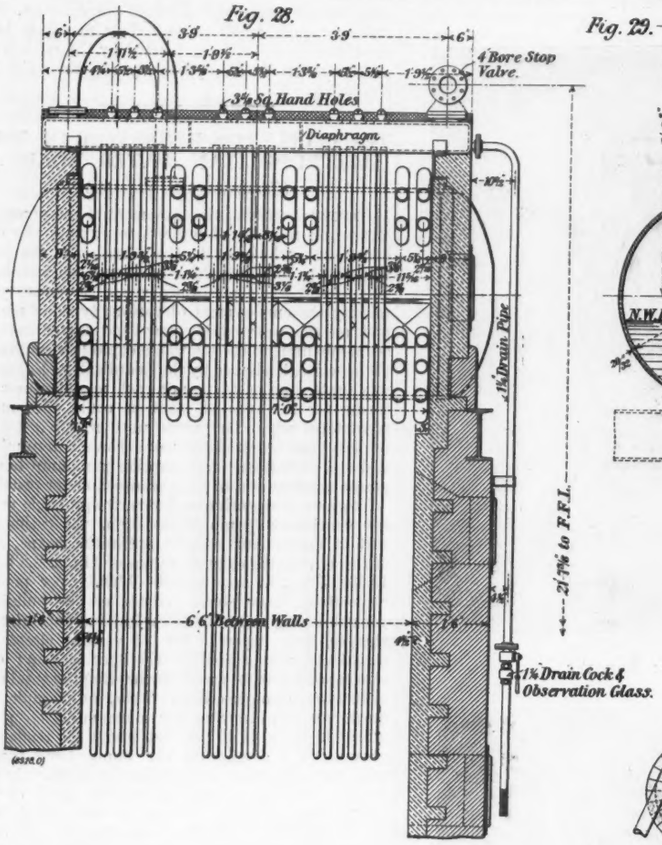


Fig. 29.

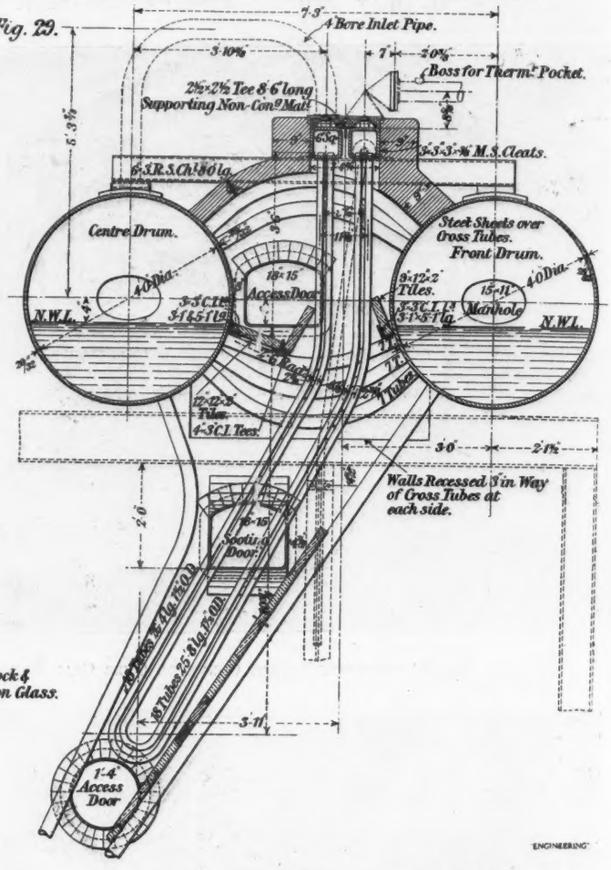


Fig. 30.

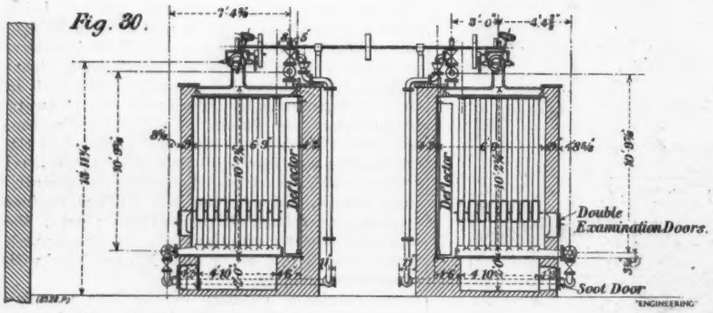


Fig. 31.

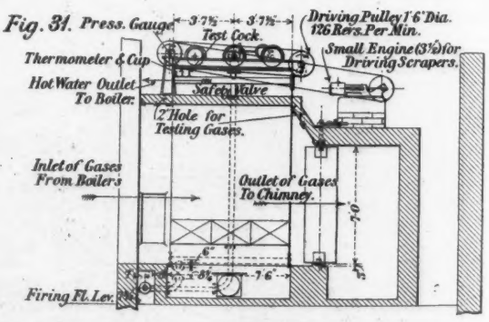
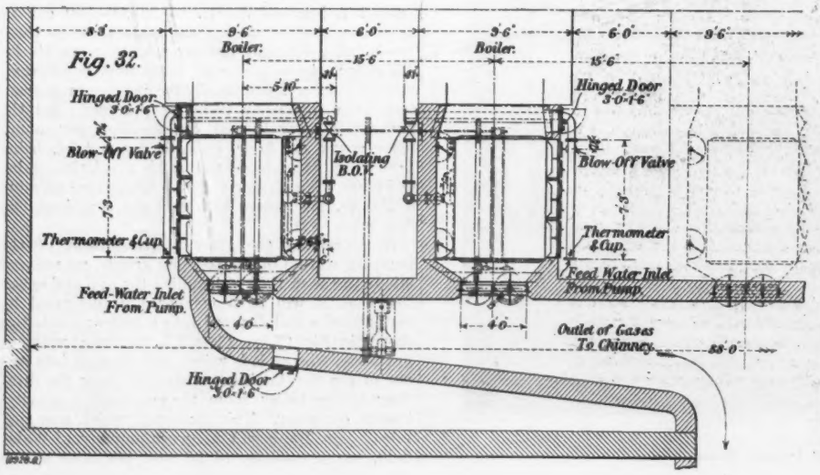

Press. Gauge
Test Cock.
Driving Pulley 1'6" Dia. 126 Revs. Per Min.
Small Engine (3½") for Driving Scrapers.
Thermometer & Cup
Hot Water Outlet To Boiler.
Safety Valve
2" Hole for Testing Gases.
Inlet of Gases From Boilers
Outlet of Gases To Chimney.
Firing Fl. Lev.

Fig. 32.



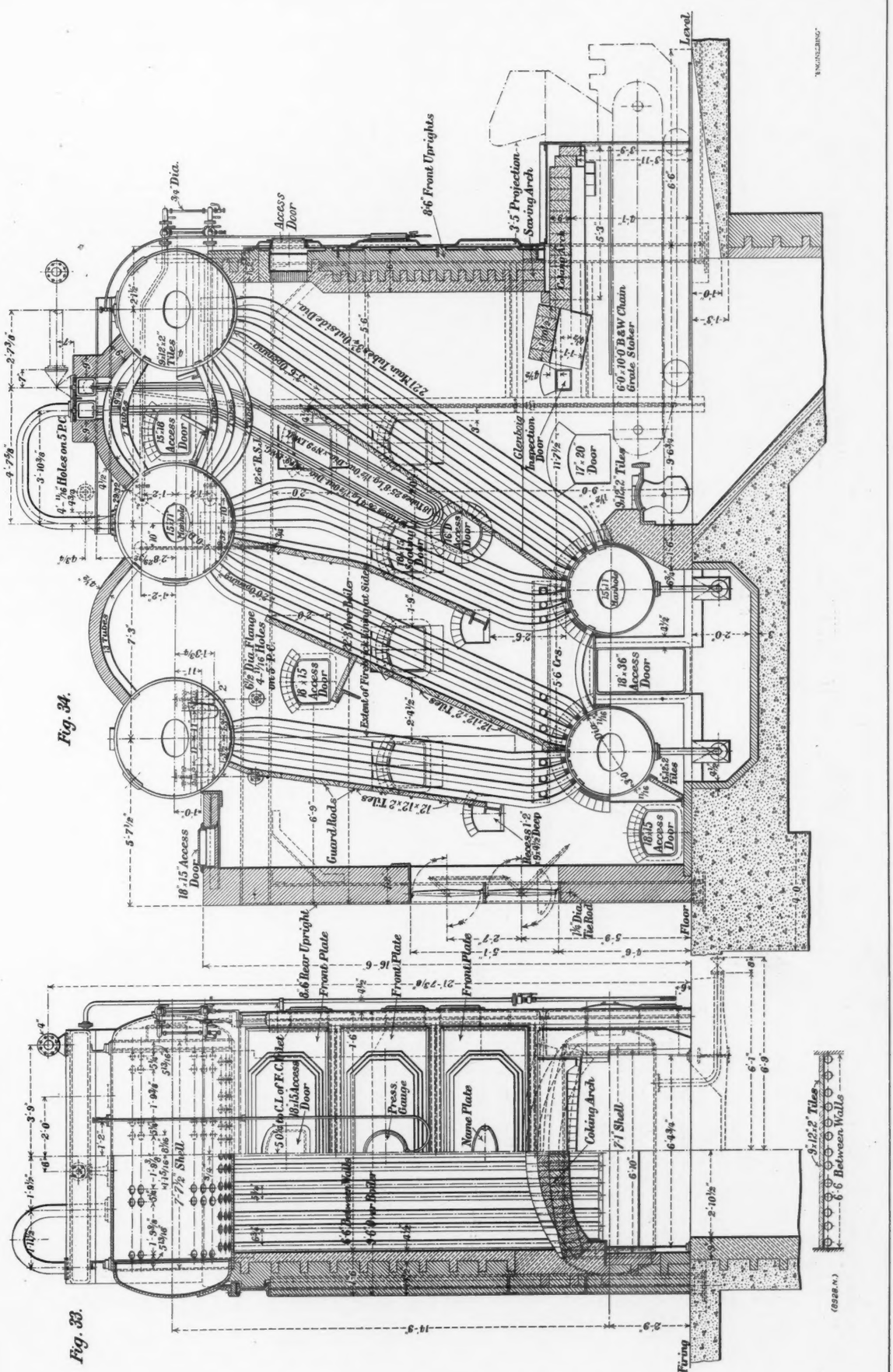
driven electrically. The horizontal portion of the conveyor running along over the tops of the bunkers is shown in Fig. 26 on page 627, while Fig. 27 on the same page shows two of the boilers as erected at the eastern end of the boiler room. The chutes leading down from the bunkers to the hoppers of the stokers can be seen in the latter illustration, and it will also be noticed that the central bunker, which will supply an additional boiler, if required, is provided with a cylindrical chute used in the meantime for supplying coal for an auxiliary boiler. The same illustration shows, on the left, the small glazed compartment forming an instrument room, as mentioned on page 596 *ante*, and containing a "W.R." CO_2 indicator, a pyrometer with connecting leads to various parts of the boiler settings, and indicating and recording gauges for the steam pressure.

Drawings of one of the boilers and of its setting are reproduced in Figs. 33 and 34 on Plate XLII which accompanies this issue, while Figs. 28 to 32 on this page, illustrate the superheater and

STIRLING BOILER FOR THE LITTLETON RESERVOIR PUMPING STATION.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description see Page 627.*)



(*To face page* 628.)

PUMPING PLANT FOR THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description, see Page* 627.)

Fig. 35.

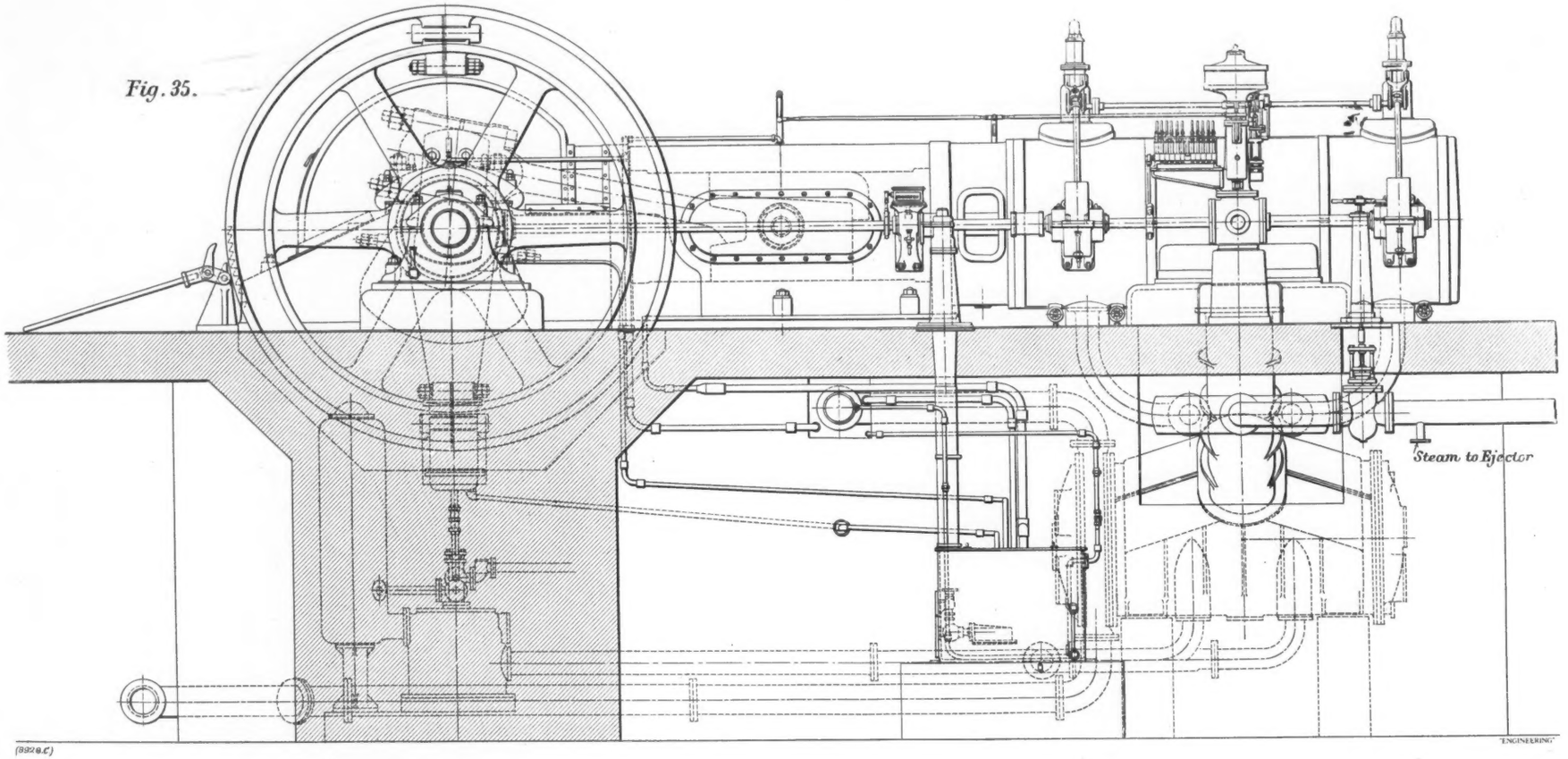
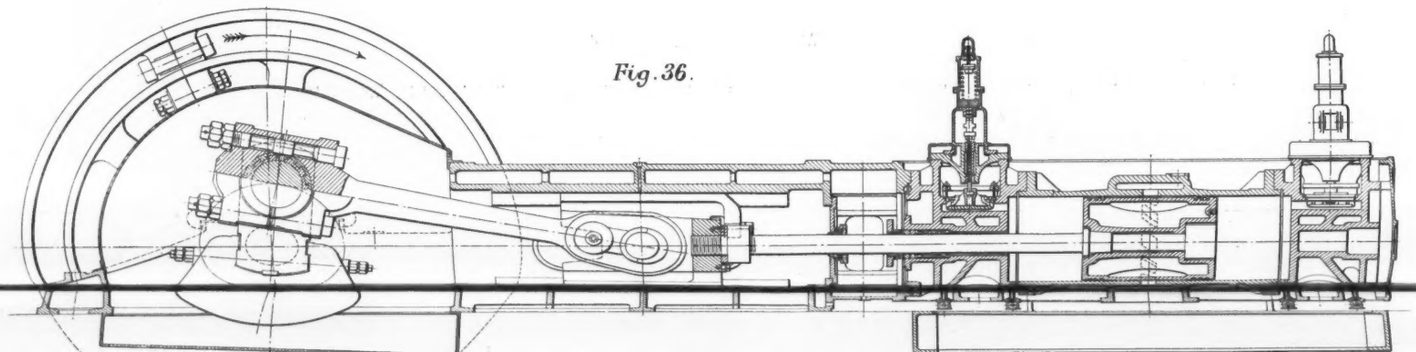


Fig. 36.



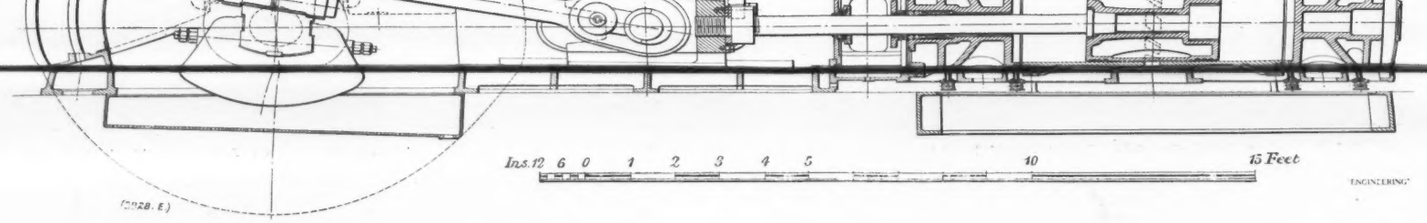
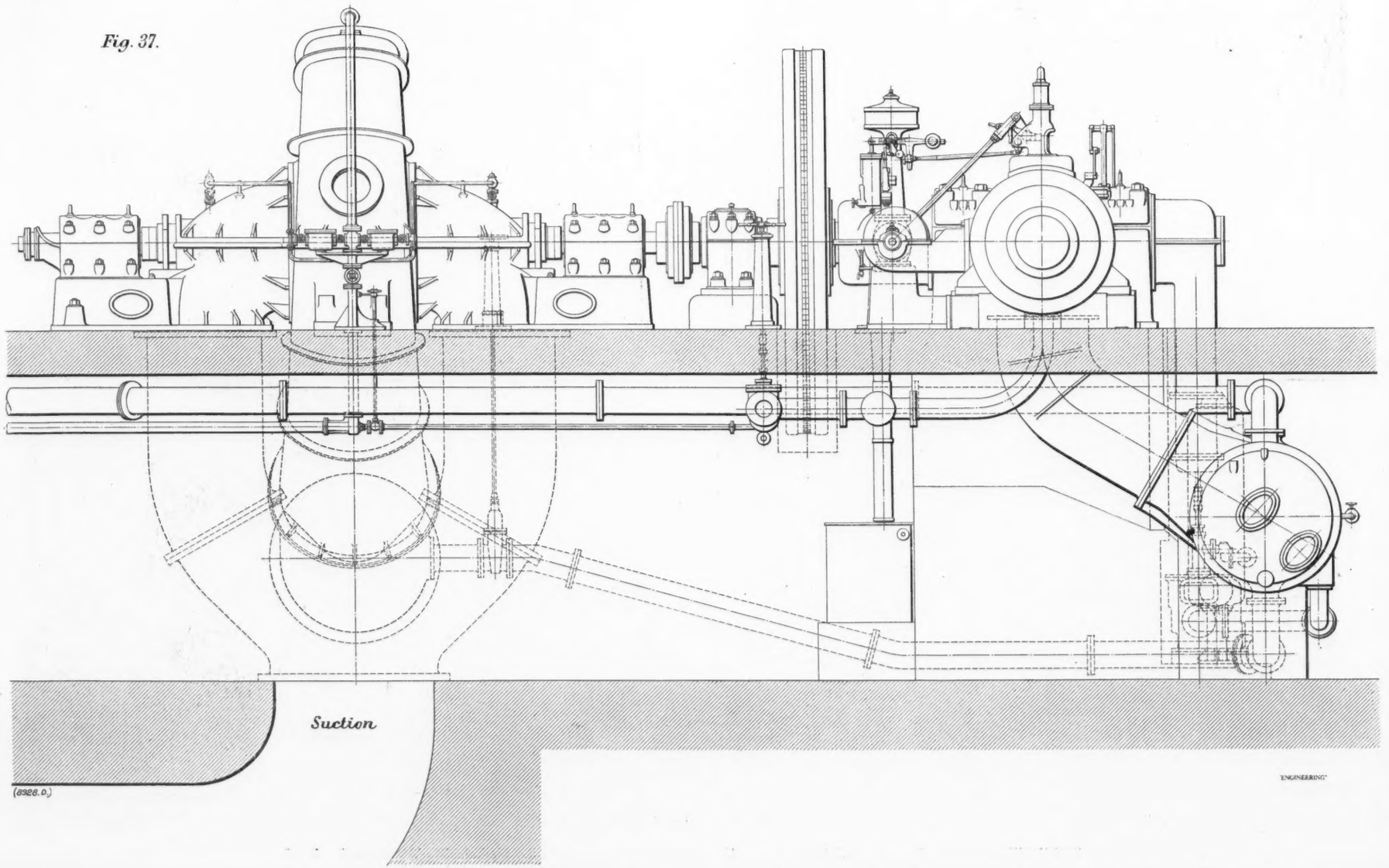

Ins. 12 6 0 1 2 3 4 5 10 15 Feet
(8928. E.)
"ENGINEERING"

Fig. 37.


Suction
(8928. D.)
"ENGINEERING"

DELIVERY MAINS AND OUTLET WORKS OF LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(*For Description, see Page* 627.)

FIG. 38. DELIVERY MAINS UNDER CONSTRUCTION AT PUMPING STATION.

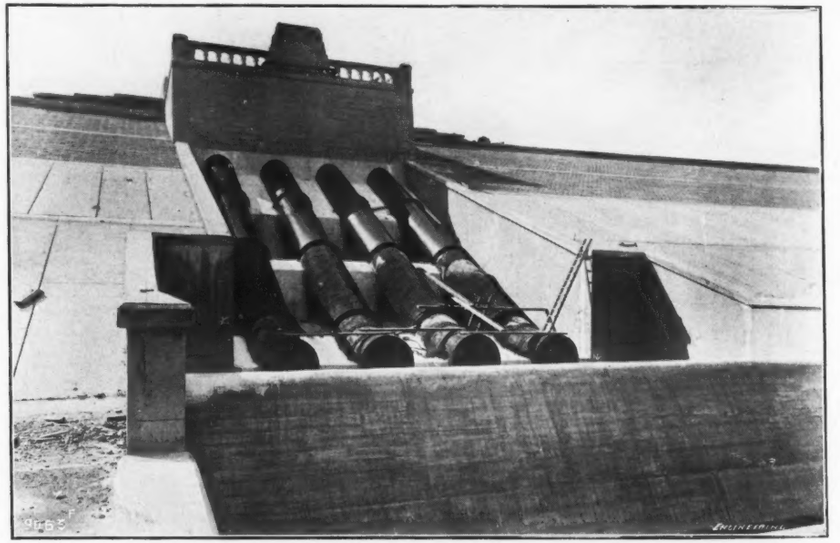


FIG. 39. DELIVERY MAINS AND MASONRY EMBAYMENT ON WATER SIDE OF RESERVOIR.

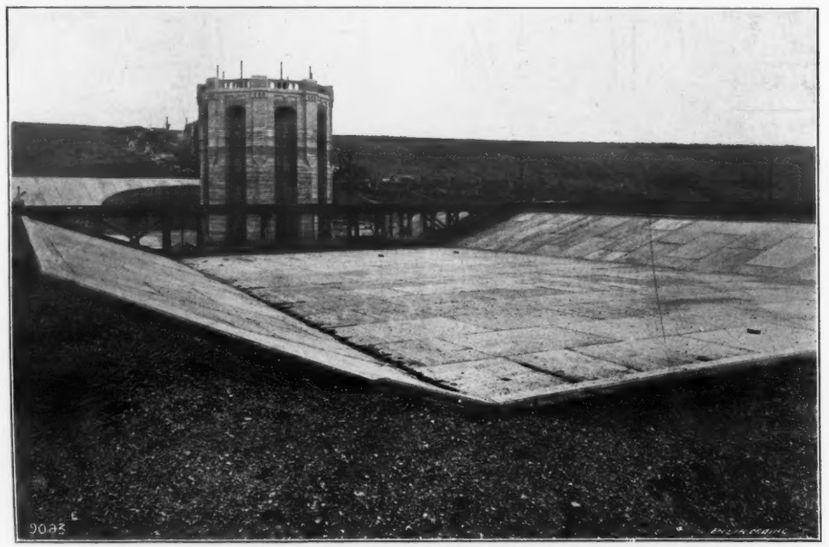


FIG. 40. FOREBAY AT OUTLET TOWER.

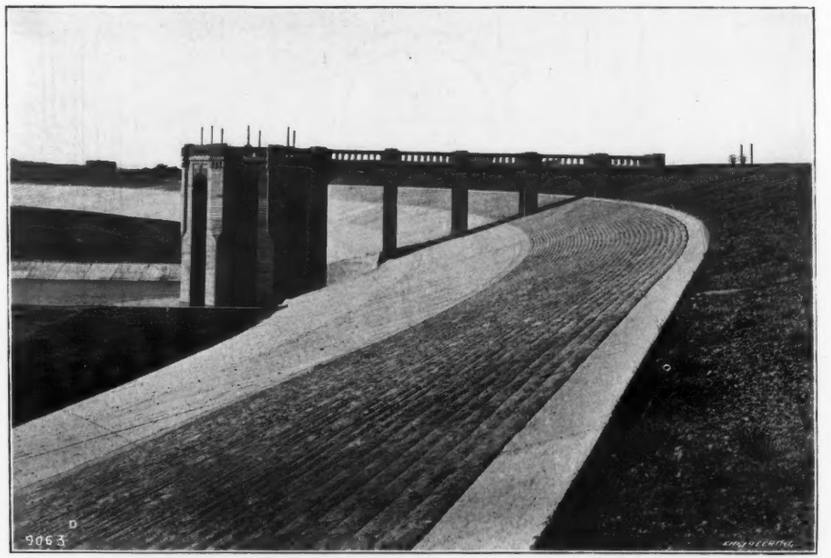


FIG. 41. OUTLET TOWER AND ARCHED ACCESS BRIDGE.

(*To face page* 629.)

PUMPING PLANT FOR THE LITTLETON RESERVOIR.

PUMPING PLANT FOR THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

FIG. 42. 770-H.P. WORTHINGTON-SIMPSON SINGLE-CYLINDER UNIFLOW ENGINE OF PUMPING SET.

economiser with which each of the boilers is fitted. As previously stated, the boilers, of which four are now installed, were constructed by the Stirling Boiler Company, Limited, 32, Farringdon-street, E.C.4, each having a grate area of 60 sq. ft., a heating surface of 2,808 sq. ft., and an evaporative capacity of 8,300 lb. of water per hour to steam at 200 lb. per square inch with 200 deg. F. superheat. The boilers are all set singly, and each normally supplies one pumping set, forming a complete self-contained unit, but, by means of a cross main provided, the steam from any one boiler can be supplied to any one of the engines. As will be seen from Figs. 33 and 34 on Plate XLII, the boilers are of the standard Stirling type with three steam drums 4 ft. in diameter internally, and 9 ft. 1 in. in length overall, while the corresponding dimensions of the mud drums are 3 ft. and 8 ft. 4 in. The main tubes, 221 in number, are 3½ in. in diameter externally, while those of the superheater number 36 and are 1½ in. in outside diameter. It will be seen from Fig. 33, that steam is taken from the central drum through a 4-in. bore bend to one of the steel headers of the superheater, which are 6 in. square internally. The superheater tubes are arranged in three groups of 12 each, as shown in Fig. 28 on page 628, and after passing through each of the groups in series, the steam leaves from the main stop valve mounted on the front header. Flanged connections, consisting of weldless steel tubes, are provided on the headers for the inlet and outlet branches, and hand holes fitted with covers give access to the tubes for cleaning, as shown in Figs. 28 and 29. Fig. 28 shows the 1¼-in. drain pipe connected to the outlet header and fitted with an observation glass so that the attendant can ascertain that the superheater is free from water.

Each boiler is fitted with a chain-grate stoker of the Babcock and Wilcox type, giving a grate 10 ft. long by 6 ft. wide, the stokers for the four boilers being driven by two small steam engines. The stokers are of the standard pattern, and call for no particular comment, but it may be mentioned that each of the hoppers is fitted with a Lea coal meter which indicates the coal consumption per square foot of grate area per hour, and also the total quantity burnt. A Green's economiser with 96 tubes, 4⅞ in. in diameter externally and 9 ft. in length, is fitted at the back of each boiler, and Figs. 30, 31 and 32 on page 628 show the arrangement of two of these with the necessary flues, dampers and scraping gear; the latter is driven by a small steam engine as will be clear from the illustrations. Before leaving the boiler-house equipment we should mention that one of Messrs. Davey, Paxman's "Economic" boilers, measuring 5 ft. 6 in. in diameter by 10 ft. long, has been installed to supply steam at 200 lb. per square inch to two electric generating sets when the main boilers are out of action. The generating sets are located in the main engine room, and each consists of a 25-kw. continuous-current generator by the Lancashire Dynamo and Motor Company, Limited, Manchester, directly coupled to a high-speed steam engine made by Messrs. Ashworth and Parker, Limited, of Bury. These sets supply power for lighting, and for operating the coal conveyor, ash hoist, and various other auxiliaries.

In describing the pumping sets it will be convenient to deal first with the engines, one of which is shown separately in Fig. 42 above. Figs. 35 and 36 on Plate XLIII are an elevation and longitudinal section of the engine, while Fig. 37 is an end elevation of an engine shown coupled to a pump. Photographs of the latter are reproduced in Figs. 43 and 44 on page 630, while Fig. 45, on the same page, is a longitudinal section of the pump, and Fig. 46 is a half-side elevation and a half-transverse section through the casing showing the impeller. Each engine develops 770 brake horse-power when running at 140 r.p.m. and delivering 62,500,000 gallons a day of 24 hours against a head of 46 ft., the overall efficiency under these conditions being 79 per cent. The maximum efficiency of 81 per cent, however, is obtained when running at 130 r.p.m. and delivering against a head of 37 ft., the brake horse-power developed then being 720, and the delivery amounting to 75,000,000 gallons a day for each set. At a 30 ft. head, each set will deliver 85,700,000 gallons a day when running at 125 r.p.m., the efficiency, under these conditions, being 77 per cent. and the brake horse-power 704.

The single-cylinder of each of the Uniflow engines is 28 in. in diameter and the piston stroke is 39 in., steam admission being controlled by drop valves and exhaust taking place through central ports which are uncovered by the piston at the ends of the stroke. The valves are operated by trip gear driven by a lay shaft from the crankshaft, as shown in Figs. 35 and 37, on Plate XLIII, and also in Fig. 42 on this page. A governor, driven by the lay shaft, controls the cut-off in accordance with the load, the mechanism for this purpose being shown most clearly in Fig. 37. It will be understood, from this illustration, in conjunction with Fig. 42, that the movements of

PUMPING PLANT FOR THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

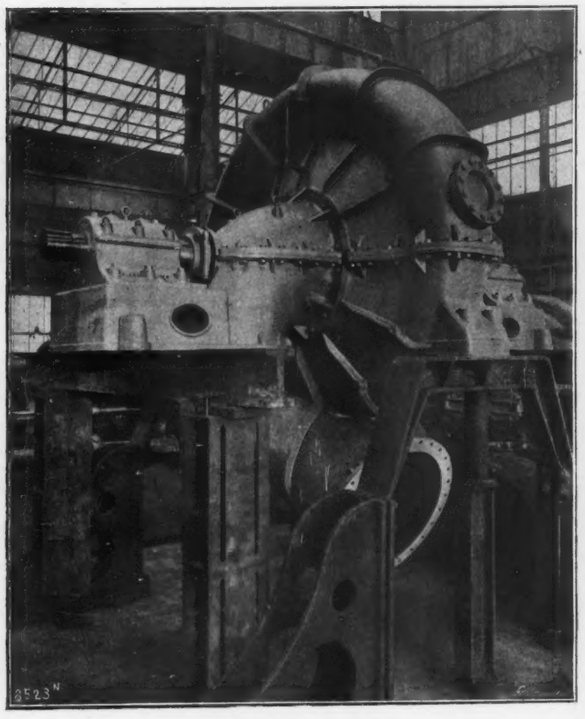


FIG. 43.

FIG. 44.

FIGS. 43 AND 44. 48-IN. LOW-LIFT CENTRIFUGAL PUMP ERECTED IN MAKER'S SHOPS.

Fig. 45.

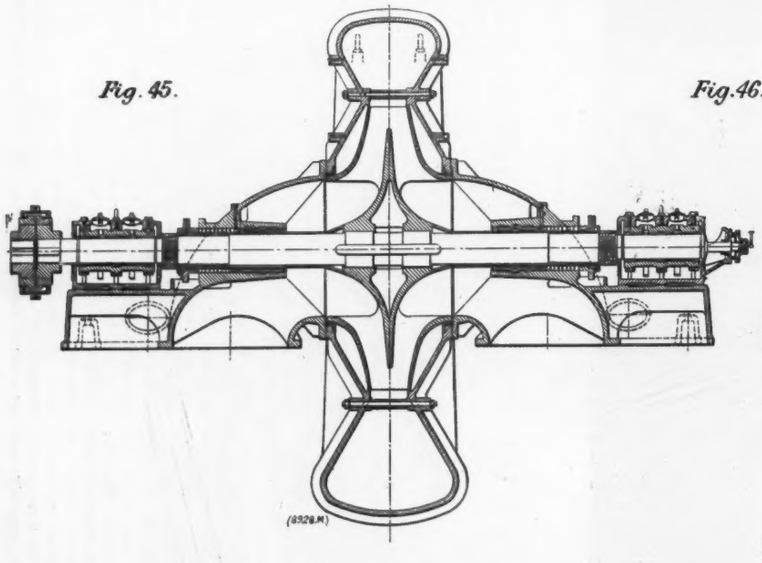
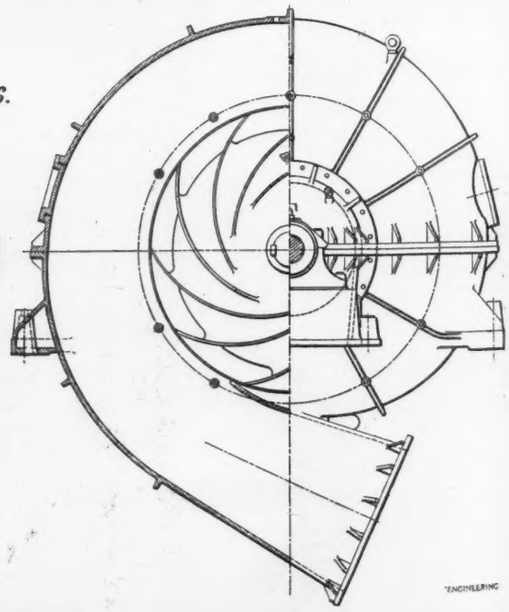


Fig. 46.



the governor rotates a horizontal shaft, on each end of which is mounted a cam engaging with a trigger operated by the valve rod. A projection on the trigger engages with a hardened-steel plate on the end of a bell-crank lever which operates the valve spindle, and the valve is released early or late in the stroke according to the position of the trigger as controlled by the governor.

The cylinder itself is not steam jacketted, but jackets are provided in the end covers, and these are adequately drained. Provision is also made in the end covers for increasing the clearance space so as to reduce the compression when starting up, the connections between the cylinder and the additional clearance spaces being controlled by hand-operated by-pass valves. The design of the piston, piston rod, crosshead and guides, and the connecting rod are clearly shown in Fig. 36, and it will also be noticed from the illustrations that the working parts are completely enclosed. The crank-shaft, which is 14 in. in diameter at the journals, is carried in two main bearings on the bed-plate, with an additional pedestal bearing on the outer side of the flywheel, which is 11 ft. in diameter, and weighs 8·3 tons. Mechanical lubrication is provided for the cylinder and piston, and for the working parts of the steam admission valves, while the main bearings are continuously supplied with oil from gravity tanks located under the roof of the engine-room. These tanks are supplied by a pump drawing from cooling and screening tanks in the basement, in which tanks the oil is collected after passing through the bearings.

Each engine exhausts into its own surface-condenser which is located in the basement under

the engine room, as shown in Figs. 35 and 37. The condenser, designed to give a 28-in. vacuum under normal working conditions, has 900 sq. ft. of cooling surface, and the necessary circulating water is supplied to it from the main delivery pipe, the water returning to the suction culvert after passing through the condenser. Dotted lines in Fig. 37 show the pipe connection from the delivery pipe, and also indicate the valve by which the flow can be controlled from the engine-room floor level. A dial thermometer is fitted in the circulating-water outlet connection from the condenser so that the attendant can regulate the flow in accordance with the temperature. The air pump is driven from the engine crankshaft, as shown in Figs. 35 and 37, the crank and connecting rod being enclosed in a cast-iron casing. A small force pump, combined with the air pump, delivers the condensate to filters located outside the building, and these filters, which are composed of ashes, serve to remove the oil before the water is returned to the feed pumps. Make-up feed is passed through an evaporator, and this, together with the filtered condensate, is measured by a Lea V-notch recorder before being pumped through the economisers into the boilers. It should also be mentioned that the exhaust from the feed pumps, stoker engines, and electric-generating sets is also utilised for feed heating by being passed through a heater in the main feed pipe.

The connection between the engine and pump shafts is made by a Wellman-Bibby flexible coupling, part of which is shown in position on the left of Fig. 42; the coupling is also shown in section on the left of Fig. 45. The general arrangement of the pumps can be followed from Fig. 37, on Plate XLIII, while a good idea of their dimensions is given by Figs. 43 and 44, on page 630, which show them erected in Messrs. Worthington-Simpson's Newark works. The impeller is of cast iron, 88 in. in diameter, its design being illustrated in Figs. 45 and 46. To balance the thrust on the impeller, suction connections are made on both sides of the casing, these connections each being 36 in. in diameter. Any residual thrust is taken on a Michell thrust bearing provided on the outer end of the shaft, as shown on the right of Fig. 45. Cast-iron flanged bends lead down, as shown in Fig. 37, on Plate XLIII, to a breeches piece which is connected to the riveted steel reducing bend embedded in the concrete of the suction culvert, as mentioned on page 595 *ante*. No foot valves are fitted in the suction connections, the pumps being charged by steam ejectors, one of which is shown in Fig. 37. The pump shaft, which is 10 in. in diameter, passes through packed glands in the casing forming the suction connections, and is supported in ring-oiled bearings at each end. Details of the glands and bearings are given in Fig. 45, which also shows the gun-metal bushes provided in the glands and stuffing-box necks. Sealing water for the glands is taken from the delivery side of the pumps, being passed through duplex filter boxes on its way to the glands in order to remove any grit or other solid matter.

It will be seen from the illustrations that the pump casing is divided on the horizontal centre line, the upper and lower portions being connected by bolts passing through heavy flanges, so that, by removing the upper portion, the shaft and impeller can be lifted out when necessary for examination or repair. Bronze rings are also fitted in that part of the casing in which the eye of the impeller revolves and these rings can be readily replaced when worn, so as to maintain the efficiency of the pump. As shown in Fig. 46, the casing is designed to form a volute diffusion chamber to which a delivery connection 48 in. in diameter is made at the bottom, the delivery pipe passing out between the two suction connections as shown in Fig. 37.

Electrically-operated sluice valves are fitted on the delivery pipes in the engine-room basement, the valves being controlled from the engine-room floor level, and, by means of tapering pieces, the outlets from these valves are connected to the four 60-in. riveted-steel mains which are carried over the embankment to deliver the water into the reservoir. The tapering connections and the horizontal portions of the delivery mains can be seen in Fig. 38, on Plate XLIV, which has been reproduced from a photograph of the site of the pumping station taken at the end of September, 1923. The suction chamber and the intake channel are also visible in the background of this illustration. The general arrangement of the pipes, however, is most clearly shown in Fig. 11 on page 596 *ante*. To prevent reversed flow due to syphonage in the event of the pump being stopped before the delivery valve is closed, reflux valves, designed to offer the minimum resistance to the normal flow of the water, have been fitted in each delivery main near the foot of the embankment of the reservoir, where the mains are dipped to pass under a small stream known as the River Ash, the course of which was diverted during the construction of the reservoir, as indicated in the plan, Fig. 1, on page 593, *ante*.

The 60-in. mains passing over the embankment are supported on a structure consisting of mass concrete arches and piers built on each side of the puddle core and extending across the width of the embankment, the mains lying in concrete saddles formed above the arches. This part of the work was described in detail on page 419 of our issue of October 6, 1922, and a section and plan of the concrete construction, mains, and of the forebay of concrete slabs over which the water is delivered into the reservoir, will be found on Plate XXXII published with that issue, to which we must refer our readers for full particulars. We may mention, however, that an ornamental masonry embayment, of Forest of Dean stone, has been constructed on the water side of the embankment since the drawings above referred to were made, and this is shown in the photograph reproduced in Fig. 39 on Plate XLIV which accompanies this issue. Manholes in the floor of this embayment, and visible in Fig. 38 on Plate XLIV give access to valves controlling connections to the delivery mains provided as a further means of preventing back flow from the reservoir due to syphonage when any pump is out of service. Connections are also made at this point to exhausters in the pumping station, so that the air collecting in the mains can be extracted and the static head against which it is necessary for the pumps to start is thus reduced to the difference in level between the water in the reservoir and that in the intake channel. To prevent the free access of air to the mains when the reservoir is empty, their lower ends are kept submerged by means of a concrete weir which, together with the side walls leading to the apron, forms a rectangular basin 50 ft. wide, 30 ft. long and 8 ft. deep. The weir can be seen in the foreground of Fig. 39, and although the lower ends of the mains appear in this illustration to be at a higher level than the crest of the weir, such is not actually the case. The weir also serves to distribute the flow uniformly over the whole width of the bay, whilst an upward curvature at the base throws the water upwards, breaking the velocity of flow on to the tailbay apron, which extends over the bed of the reservoir for a distance of 206 ft. from the toe of the dam, gradually increasing in width from 50 ft. to 155 ft. 7½ in.

The outlet works are situated at the north-eastern corner of the reservoir near Ashford Common, and, as previously stated, they consist mainly of a concrete tower constructed in the bed of the reservoir and connected by a tunnel to a concrete shaft located in the material of the embankment outside the puddle core. This part of the work was described very fully on page 481 of our 114th volume, where plans and sections illustrating the design will be found, but it is desirable to refer briefly to its general character in order to render our present account of the whole undertaking reasonably complete. The bed of the reservoir in front of the outlet tower is protected by a forebay, which is roughly rectangular in plan, measuring 240 ft. by 145 ft. over all and being composed of concrete slabs laid to form a horizontal floor with sides set to a slope of 3 to 1. Its form will be understood on reference to Fig. 40 on Plate XLIV, which shows the work at an advanced stage of construction, while the appearance of the whole outlet works, as finally completed, is well shown in Fig. 41. The outlet tower, the axis of which is at a distance of 136 ft. 6 in. from the centre line of the puddle core, is octagonal in plan, the sides being formed with recesses in which single-faced sluices measuring 5 ft. by 6 ft. are fitted. There are seven of these sluices, the sills of which range in depth from 41 ft. to 12 ft. from the water level when the reservoir is completely filled; the depth of water is then 43 ft. above the floor of the forebay. A float water-level gauge is provided in the outlet tower, the float rising and falling in a pipe to which the water gains access through holes near the bottom.

The sluices are operated by hand gearing from the top of the tower, the lower two tiers of sluices having change-speed gearing in two stages, and the water, which enters the outlet tower when the sluices are opened, flows through the tunnel to the outer shaft and, rising in this, leaves through two reinforced-concrete conduits 8 ft. in diameter. The inlets to the latter are controlled by single-faced sluices, the hand-operating gear for which can be seen on the extreme right of Fig. 41. This illustration also shows the bridge which gives access to the outlet tower. The bridge, it may be mentioned, as well as the upper part of the outlet tower, is faced with masonry of Forest of Dean stone, which has a pleasing appearance combined with excellent weather-resisting properties. It will also be noticed from Fig. 41 that the pitching of the reservoir embankment has been partially completed in the neighbourhood of the outlet works, although, as previously stated, this work will not be carried out generally until the earth of which the embankments are formed has become thoroughly consolidated.

(To be continued.)

THE GAUGING OF RIVERS AND TIDAL CURRENTS.

(Concluded from page 600.)

THE actual process of applying these arrangements to determine the discharge of a river is illustrated in Fig. 7. It will be remembered that for a constant bed the total discharge of a large river with natural flow can be expressed as a function of the water level or stage of the river. If, in fact, for various heights of the water level the elementary discharges at various depths on a vertical line are measured by current meters, a curve—the vertical velocity curve—can be drawn connecting the velocity of the stream at given depths (calculated from the meter revolutions) with the depth; the area of each curve gives the discharge past the vertical element to which it refers, and if these rates of discharge are plotted on their respective verticals, the area of a curve drawn through their extremities will represent the total discharge past the cross-section. In Fig. 7 the cross-section is plotted in the upper part of the diagram, with the vertical velocity curves below, numbered from the left bank. The discharge curve plotted above the cross-section represents at each point the rate of discharge, and its area gives the total discharge.

These total discharges plotted against water levels give the stage discharge curves; Fig. 8 shows such a curve plotted from the measurements taken at Bewdley, and Fig. 9 from those taken at Burgage Bridge. The report draws attention to certain peculiarities in these curves, and its comments illustrate the manner in which the results of the method may be interpreted. The Bewdley points are seen to fall fairly closely on two curves, one indicating a much higher discharge for given gauge readings than the other. The dates of the measurements represented by the points on the lower curve show that they were all made in summer or autumn, while with four exceptions, which occurred in the autumn of 1923, the measurements of which the plots fall on the higher curve were made in spring. It appears therefore the Severn in the district in question has two stage-discharge curves; and an examination of the circumstances of the river has led to the conclusion that these are determined by the presence or absence of weeds, which have a notable effect in decreasing the area of the cross section and increasing its roughness, the high discharge curve representing flow when the channel is clear, and the low discharge curve when the channel

is encumbered with weeds. This hypothesis is supported by the natural history of the river. Weeds decay in winter and, with the débris, are broken up and scoured away by the winter floods, leaving a clear channel for the spring measurements. On the other hand, the low water and favourable temperature of May and June promote the growth of weeds, and continues until they reach the maximum of weed growth, which seems to correspond to the minimum discharge. This condition continues, and the lower stage-discharge curve represents the discharge, until floods come and sweep away the weeds. The epochs in this cycle will, of course, fall at different times in different years; and it is noted that in 1923 early floods occurred in September, which cleared the channel, causing the measurements taken in that autumn to fall on the higher discharge curve, as in fact they did. The clear channel curve does not, it will be seen, extend to very low discharges. This may be due partly to lack of observations; but the report points out that such discharges only occur in the summer, and therefore probably never under clear channel conditions. The effect, on the other hand, of weed growth when discharges are high has not been determined, but it is pointed out that in high flows weeds can only affect a small portion of the section and would, moreover, probably lie closer to the ground under the action of the more rapidly moving water. It is therefore estimated that they would make no practical difference to the discharge when it exceeds about 4,000 cusecs. Accordingly the discharge past the Severn section is represented by the high discharge curve after the first severe autumn floods, by the low discharge during the summer, and by transitional values in May or June.

At Burgage Bridge only one stage-discharge curve exists, the flow being controlled by a fairly regularly shaped submerged weir formed by the bag concrete floor between the arches of the bridge. It will be seen that the discrepancies between individual measurements and the mean curve are larger than on the Severn, in two instances being as high as — 13 and + 11·3 per cent. respectively. Both these observations are said to have been carried out under severe weather conditions; but the discrepancies are due at least in part to the shallowness of the river (mean depth, 2·5 ft., as against 8 ft. for the Severn at Bewdley), which causes errors in sounding to have a more serious effect on the accuracy of the measurement.

An examination of the results obtained under conditions of turbulent flow shows the considerable irregularity produced in the measurements of both the Price and the propeller type instruments, the Price reading erratically high and the propeller type erratically low. The report suggests that if duplicate measurements by a Price and a propeller type meter differ by more than 2 per cent., a fresh section of river should be chosen. If this is impossible, a screw meter with cylindrical guard ring, like the Stoppani, should be used.

The experience of the Severn conditions, which are typical of those of many rivers in the United Kingdom, shows that the use of stage-discharge curves may be misleading without sufficiently frequent observations to allow changes in conditions to be followed, and some judgment in taking account of them. With many other streams the method is not only open to this objection, but is actually inapplicable. These streams include small streams and mountain torrents, with rough and changeable beds and irregular flow, many of which may be of considerable importance both for power and for domestic supplies, and the considerable class of rivers and streams that are controlled artificially by mills or other works, in which the gauge height is no measure in itself of the discharge. For measuring the discharge of such streams, which would probably be the first business of a hydrometric survey, the most convenient method usually involves some form of weir; that is to say, some obstruction of regular section placed across the channel of a stream, so that the entire discharge flows over it. The report contains an account of the principal types of weir and of the empirical formulæ that express the discharge in terms of the head on the weir. Calibration by measurements on scale models, checked by full-size measurements of flow with current meters to verify the assumptions made in computing the total flow from special weirs and sluices, or from existing weirs and sluices made for the control of streams, can also be used for measurement. Where a weir can or has to be put in specially, the type recommended is a sharp-edged weir without side contractions; that is to say, one in which the nappe or falling water touches only the sides and not the upper part of the downstream face of the dam. Fig. 10 shows a suitable general arrangement for a weir of this type. The crest is formed by a brass strip inserted in a steel angle, which has ⅞-in. holding-down bolts in 1-in. holes to allow for the final adjustment of the position of the crest. Some other 1-in. holes are drilled in the lower leg of the angle for grouting. The top of the crest and the face of the angle are planed smooth, flat, and at right angles. The front of the dam must be made vertical, and the front of the crest set exactly in the same line. The gap between the top of the dam and the angle—usually about ¼ in.—is pointed with cement, and the space beneath the angle grouted up. Air holes are set in the side walls below crest level on the downstream side of the weir, to prevent the air between the nappe and the face of the dam from being exhausted, and the nappe from consequently touching the face and thus increasing the discharge, and care must be taken to prevent these holes from becoming choked. The crest is erected on a timber or concrete wall, which must not project downstream far enough to interfere with the nappe at low flows. The side walls must be truly vertical and at right angles to the crest, extending upstream to a length of at least six times and downstream to at least twice the maximum head. It should not be used for heads below 0·5 ft., at which the formulæ cease to be trustworthy, but as, normally, a weir cannot be constructed with such a head at minimum flow and still be able to pass the flood discharge, two weirs are often used, one for the low flows, and one with its crest at a higher level for the floods. Where possible, the crest should be at such a height as prevents it from ever being submerged by the tail water, so as to avoid the need for observations of the tail water level and the use of submerged-weir formulæ. Recorders, in some form of gauge well, are usually desirable for weirs on small streams; the measurement should be made upstream at a distance greater than three times the maximum head. Measures must be taken periodically for correcting the discharge curve of the weir where silting has occurred, and generally for inspecting the stability of the weir structure, the

Fig. 7. RESULTS OF A CURRENT METER GAUGING.

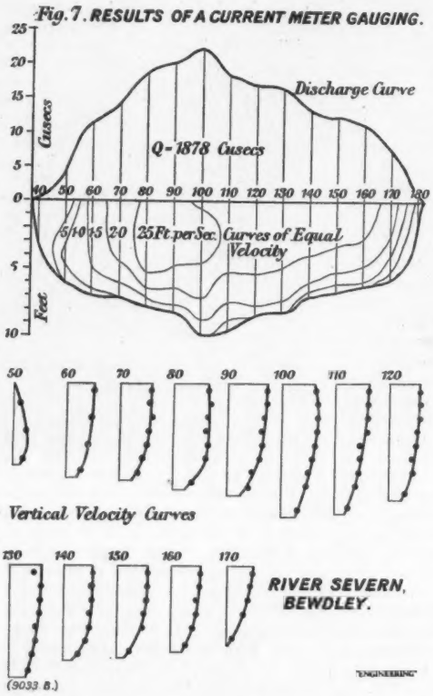


Fig. 8. STAGE DISCHARGE CURVES FOR THE RIVER SEVERN AT BEWDLEY, 1921-23.

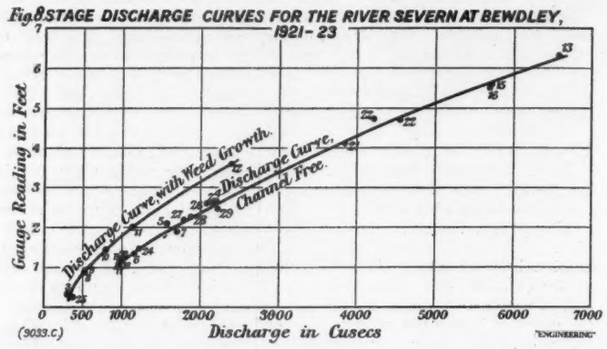


Fig. 8. STAGE DISCHARGE CURVE FOR THE RIVER LIFFEY AT BURGAGE BRIDGE, 1922-23.

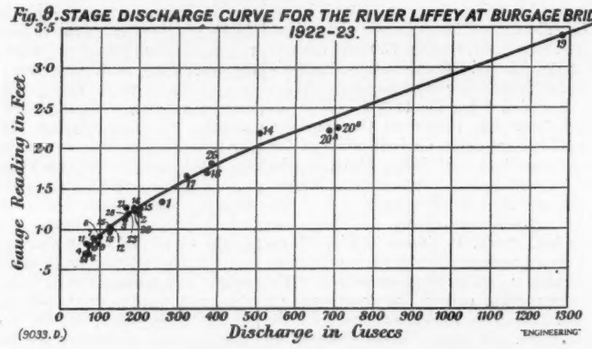
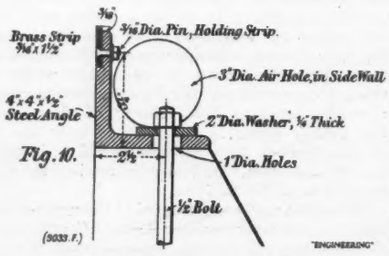


Fig. 10.



condition of the crest, and the relation of the level of the crest to the zero of the scale or recorder, referred to an Ordnance or special Bench Mark some distance from the weir.

The limit of accuracy that can reasonably be sought in weirs for stream gauging is put in the report at about 2 per cent., having regard to the accuracy obtainable in measuring such factors as the head and the velocity of approach. This accuracy can be attained for heads not lower than 0·5 ft.; and for gauging small or mountain streams or waters under artificial control, weirs will have to be used in any survey. Such accuracy, however, is quite insufficient for purposes such as tests of water turbines and pumps, and even for the measurement of filtered water, and the report urges that for these important purposes further experiments should be undertaken to raise the accuracy attainable by the use of weirs, especially with heads up to about 1·0 ft., where the greatest uncertainty exists at present.

THE IRON AND STEEL INSTITUTE.

(*Concluded from page* 598.)

CONTINUING our Report of the recent meeting of this Institute we have now to deal with the proceedings of Friday, the 8th inst.

TEMPER-BRITTLENESS.

The first paper taken was by Dr. R. H. Greaves and Mr. J. A. Jones, entitled "Temper Brittleness of Steel; Susceptibility to Temper-Brittleness in Relation to Chemical Composition," and the note by Mr. W. T. Griffiths entitled "Nitrogen as a Possible Factor in Temper-Brittleness" was considered together with it. These papers were reproduced in abridged form on pages 623 and 619 *ante*.

Dr. W. H. Hatfield, referring to the first paper, said he wished to take exception to some expressions used. The authors spoke of tough and brittle steels; they should have used the terms "notch-tough" and "notch-brittle." The brittleness referred to was only disclosed when the specimen had been notched. He would have preferred the experimental evidence submitted to have been amplified by outside tests. When giving the results of one test it was always well to ascertain that these were balanced by the figures supplied by other tests. Turning to the effect of composition, Dr. Hatfield pointed out that three chromium steels, each containing 0·4 per cent. of carbon and 1·6 per cent. of chromium, but with manganese contents of 0·22, 0·60, and 0·91 per cent., had all been subjected by the authors to the same tempering process. He submitted that it would have been preferable to take each steel separately, ascertain the tempering temperature called for by the composition, and vary the tempering treatment accordingly. That the introduction of high notch-toughness by quenching in water from the tempering temperature led to the production of severe internal stresses, was very interesting indeed. Dr. Hatfield very much questioned whether the remedy for temper-brittleness was as simple as the authors suggested. While there was a good deal of truth in the statement that the addition of 0·3 to 0·5 per cent. of molybdenum rendered the steel less susceptible to temper-brittleness, molybdenum did not invariably have that action. Moreover, molybdenum did not give a high impact value; the maximum lay between 30 and 50 ft.-lb., and this was not high. Again, molybdenum was an extremely expensive material, and its use was only justified in cases in which an alloy of high tensile strength and ductility was required.

Dr. Greaves, in reply, stated that he accepted Dr. Hatfield's correction as to the employment of the terms "notch toughness" and "notch brittleness"; in reading the paper the word "notch" had been omitted for the sake of brevity. With regard to the second point raised by Dr. Hatfield, he stated that tensile and other tests had been carried out, but they had been left out of the paper so as to keep the length of the latter within limits. Their desire had been to concentrate attention on the notched-bar tests. The results of tensile and other mechanical tests had been published in Research-Department reports and, if desired, reference could be made to those reports. He quite agreed as to the seriousness of internal stresses produced in material water quenched after tempering. This had been shown by the low elastic limit obtained from specimens treated in this way. With regard to the influence of molybdenum, he stated that the authors had only considered the effect of that metal in reducing susceptibility to temper-brittleness. The sole question dealt with by the paper was that of temper-brittleness, and it appeared quite definite that molybdenum did eliminate that defect.

"PEELING" IN MALLEABLE CAST IRON.

The third paper dealt with was by Messrs. D. H. Ingall and H. Field. It was entitled "'Peeling' in White-Heart Malleable," and was read in abstract by the former. We reproduce it in abridged form on page 654 of our present issue.

Professor Turner, who opened the discussion, stated that he quite agreed that the faster the rate of heating to the annealing temperature, the greater by far was the liability to produce peeling. This was the case even when the cast iron was sulphur-free and of suitable composition. Impure materials had to be used, however, and English commercial cast iron was rich in sulphur, usually containing from 0·33 to 0·35 per cent. of that element. He did not quite know why this was the case, the Americans used an iron containing less sulphur, and there was no real reason why the sulphur-content of our iron should not be lower. Experiments made on the influence of sulphur upon the mechanical properties of iron had shown that, within ordinary limits, these did not appear to suffer. This explained, perhaps, why the cast iron had been so long considered satisfactory. The presence of silicon tended to throw iron sulphide out of solution, and this had, no doubt, some bearing upon the conclusion drawn by the authors that the higher the silicon-content, the greater was the liability to peeling. In the binary system iron-iron sulphide, a eutectic occurred at 985 deg. C., and this contained 85 per cent. iron sulphide and 15 per cent. iron. The authors stated that temperatures in the neighbourhood of 950 deg. C. were most conducive to peeling. At these temperatures iron sulphide was mobile, and it was possible that pressure could squeeze it out. Some of the sulphide passed out into the hematite ore, but the amount so released was relatively small, nearly as much sulphur being left in the malleable as had been present in the original casting. The acceleration of peeling by the iron sulphide might be due to the fact that in its mobile state the latter was more readily oxidisable than iron. The influence of carbon upon iron sulphide was open to conjecture, and it was possible that there existed some combination between the two, especially at high temperatures.

Dr. W. H. Hatfield said that the conclusions formed by the authors were in line with the deductions which he had himself arrived at. He had not been satisfied, however, as to the mechanism of the process. He agreed that high temperature and high silicon content were both largely instrumental in producing peeling. Professor Turner's contribution to the discussion had greatly interested him, and he wished to add that there was definite evidence pointing to the direct combination of sulphur and silicon with the formation of sulphur silicide. With regard to Professor Turner's query as to why an iron containing 0·3 per cent. of sulphur was used in the production of malleable castings, he would say that up to 30 years ago the only iron available in Europe was one low in silicon, and, therefore, high in sulphur. Low-silicon material was necessary in the manufacture of malleable cast iron. In America matters were on a different footing, and he doubted as to whether peeling could occur in American "black-heart" malleable cast iron.

Professor W. Campbell, referring to a remark made by Professor Turner, stated that the oxidisation of the iron sulphide depended largely on the amount of manganese present in the iron. Further, the eutectic of iron and iron sulphide, of which he had spoken, was really a ternary system consisting of iron, iron sulphide and iron oxide. With regard to questions of time and temperature, it was necessary to refer to the work of Schenk dealing with reactions which took place between iron, iron oxide, carbon monoxide and carbon dioxide at temperatures below that of malleabilisation.

Dr. W. Rosenhain's remarks were chiefly confined to the formation of eutectics. He was desirous of uttering a word of warning against arriving too hastily at conclusions in the matter of eutectics of iron sulphide and iron. It was necessary to know a great deal more about the intricate systems present in a material of such a complex nature as white cast iron. Iron sulphide was not bound to be fluid at a temperature of 950 deg. C.; its melting point might be altered by other ingredients present in the alloy. Caution should be exercised with reference to the interpretation of the equilibria involved. In regard to cast iron high in sulphur, processes of desulphurisation were being worked satisfactorily and better and sounder castings had resulted. The processes had been employed not so much for the production of malleable castings as for other purposes. They could, however, be applied quite cheaply in the malleable-iron foundry if the presence of sulphur were disadvantageous.

In replying to the discussion, Mr. H. Field said the malleable industry seemed to lag behind in the matter of applying science to its processes. Their statement that information in published work was very scanty referred only to peeling. They had limited their discussion entirely to that phenomenon; they were familiar with Dr. Hatfield's book on cast iron, and had obtained much help from it. The difference between the sulphur contents of English and of American malleable was due to the fact that, in England, cupola melting was used, whereas, in America, they utilised open-hearth furnaces for the purpose. With cupolas, it was impossible to obtain low percentages of sulphur in the iron, as the metal was in contact with the coke. We could not produce "black-heart" malleable castings in this country until the open-hearth furnace had been installed in foundries. With regard to the mobility of sulphur in the castings, there was a considerable movement not only outwards but within the specimen itself. In some cases, they found more sulphur in the specimen at the conclusion of the operation than had been there at the beginning. They had not tried compositions identical with American black-heart iron, but one of their samples containing 0·068 per cent. of sulphur and 0·69 per cent. of silicon came as near that composition as they could get. With reference to the percentage of manganese and its effect in preventing peeling, it should be borne in mind that any appreciable manganese content retarded the malleabilisation process. This was why "can-material" was made of an alloy containing a high percentage of manganese.

HARDNESS TESTING.

"Some Notes on the Use of a Diamond Pyramid for Hardness Testing," by Messrs. R. L. Smith and G. E. Sandland, was the next paper taken.

In an endeavour to increase the accuracy and reliability of plastic-indentation hardness tests, the authors decided to investigate the possibilities of a diamond cut to the form of a square-based pyramid, in place of such well-known indenters as the steel ball and steel cone. The chief advantages were that the surface impressions obtained were well defined, and, being square, could be measured with very great accuracy across the diagonal corners. Again, the deformation of the indenter was practically nil, owing to its extreme hardness. The loads applied did not exceed 100 kg., but the small impressions obtained were found very satisfactory. The standard pyramid adopted had an angle of 136 deg. across the facets. The testing machine used in the investigation was described in ENGINEERING of April 25, 1924, page 518. It was found that while similarity in the hardness numerals from pyramid and ball impressions was obtained in the lower regions of hardness (where the steel ball did not undergo any appreciable deformation), at approximately 525 Brinell hardness, there was a slight, but definite, tendency for the steel ball to yield lower readings than the diamond pyramid.

This tendency increased with increase in hardness until it became very pronounced indeed.

Professor Turner, in opening the discussion, remarked that the recording of hardness in the case of very hard materials was a subject which was of great interest to steelmakers and also one which presented considerable difficulty. The relative hardness of softer materials belonging to grades 1, 2 and 3 at the lower end of Moh's scale could be easily recognised. It was very difficult, however, to distinguish relative hardness in the upper region, *i.e.*, grades 9 and 10 of Moh's scale, and when one approached, say, 400, 500 and 600 Brinell, the difficulty was very similar. He had devised a method of scratch testing and had attempted to correlate Brinell with scratch-test figures in what he might term the "high altitudes." As hardness increased, however, so did the width of the scratch decrease more and more until, in the high region, it was difficult to determine that width. Unless there were further developments in the scratch hardness-test method, he did not see how accurate quantitative values could be arrived at for the greater hardnesses. This led to other methods of testing. The indentation method as represented by the Brinell process gave rise to difficulties when testing the harder materials; the greater the hardness, the smaller was the indentation. He, therefore, welcomed the suggestion by the authors of introducing a diamond indenter of definite shape and definite plan.

Sir Robert Hadfield was rather against the new method described in the paper and thought it might be preferable to pay greater attention to improving the Brinell tests which were rendering good service. He instanced the projectile and its point, and the armour plate, both of which were of the same hardness, about, say, 650 Brinell, and the first had to destroy the second, or the second to withstand the shock of the first. The kind of hardness to be determined was that of two steels having the same Brinell value, the one treated in a special way and the other merely hardened, the result being a difference in their toughness. The Brinell test did not make it possible to determine what he might term "toughness-hardness," and he did not think the authors' method would make this possible either. The British Engineering Standards Association had appointed a committee for the standardisation not only of tests, but also of the expressions used to indicate hardness, and he thought the authors might get in touch with that committee.

Mr. Hugh O'Neill thought the authors had put forward a very sound system by which hardness values up to 1,000 Brinell could be obtained. The rate of loading and the time during which the load was applied had, however, to be investigated. He showed how, when testing cold-rolled materials by means of the authors' machine, the indentation, instead of being square in plan, had sides which bulged outwards. The metal piling up along the flat sides of the square, seemed to indicate that cold-rolled material resisted flow. Some modifications of the method would, therefore, have to be devised in order to adapt it to the testing of cold-rolled material. In soft annealed metal, on the other hand, the sides of the square indentation, instead of bulging outwards, were very slightly concave, the piling up of the material taking place at the corners of the square indentation.

Mr. A. Hultgren said that the authors had chosen their scale of hardness by keeping the angle of the pyramid constant, and they were probably right in saying that thereby they arrived at the true hardness value. There was a possibility of a variation in accuracy in the manufacture of a diamond pyramid, however, while a steel ball could be very accurately made.

Professor H. Louis understood the authors had chosen a pyramid with an angle of 136 deg.; it was difficult to grind this with accuracy. The equiaxial octahedron was the form in which the diamond crystallised and, when under pressure, it was apt to split along those planes. He suggested using the natural angle of crystallisation of the diamond; it was less liable to cleave when in use, and would no doubt prove advantageous in other ways. He asked whether the authors had tried using balls of sapphire—he meant the Ceylon opaque sapphire, which was not a difficult material to work, and having no marked cleavage was, therefore, not likely to fracture.

Mr. A. V. de Forest said that in the United States the diamond-indentation principle was also used for ascertaining hardness, especially in the case of tool steels. The Rockwell hardness tester was utilised extensively; in this machine the depth and not the diameter of the impression was measured. A first indentation was obtained by means of a 10-kg. load, and a second deeper one by means of a 150-kg. load. The difference between these two depths was read off directly on a dial, which was quicker than measurement by cross-hairs used in conjunction with a microscope. The diamond had proved a successful indentation tool for hardness testing machines. The method he had alluded to was useful in determining the higher ranges of hardness. It had not the advantages of producing indentations having sharp corners, but cold-worked material could be easily distinguished under the microscope by the asymmetry of the hole.

Professor S. L. Hoyt stated that the square indentations obtained by the authors could be very accurately measured. Further, the "geometrical symmetry of the impressions irrespective of size" was a principle similar to that involved in the Ludwik cone test. As Sir Robert Hadfield pointed out, two metals of equal hardness might behave differently, and it had been shown that the property of hardness could not be indicated by any one figure; it was necessary to have two empirical constants. If cold-worked copper and mild steel were subjected to a hardness test, the copper would be found to be the harder, but this was not really the case. It was necessary therefore to ascertain the whole of the hardness curve; to know the hardness at one point of it was not sufficient. A ball made of a material which was essentially tungsten carbide had been tried in the United States, and had been found vastly superior to the ordinary steel ball. It did not deform when loaded to 3,000 kg. upon a steel of 700 Brinell hardness. It seemed desirable to keep to balls, and this material appeared to be an ideal one for use in conjunction with the Brinell test.

Mr. T. H. Turner thought it was a pity the authors had adopted a pyramid having 136 deg. across the facets, the tangential angle of impression of a Brinell ball. He asked them if they had tried a pyramid having an angle of 45 deg.; he thought such an indenter might give figures more comparable with tensile and compression tests. He stated that, in Brinell testing, all materials suffered a characteristic deformation. In the case of steel, a raising of the material took place round the indentation while, in the case of copper, a falling away of metal occurred round the impression. Fry's etching method showed up the deformation which took place round the edges of the indentations.

[The authors' reply to the discussion will be found in a letter on page 637.]

MARTENSITE AND TROOSTITE.

In the absence of the author, "Observations on Martensite and Troostite," a paper by Mr. J. H. Whiteley, F.I.C., was taken as read.

In his paper the author stated that his aim was to trace the origin of the structures grouped under martensite. At least four types of martensite were distinguished in rapidly quenched steels. Type I was that of the well-known felted or acicular structure, and was found in steels containing up to about 0·60 per cent. of carbon. Type II was found in the comparatively narrow range between about 0·60 and 0·75 per cent. Larger, clearly defined crystallites were numerous, while the acicular structure might be almost entirely absent from many of the grains. Type III occurred in steels with a carbon content between 0·75 and 1·60 per cent. and consisted of lenticular plates and crystallites, embedded in a minutely pitted dark ground-mass. Type IV appeared in steels containing more than 1·60 per cent. of carbon which were known to be austenitic when quenched. In the author's earlier experiments, the specimens were quenched in ice-brine at a temperature of about — 15 deg. C. Later, he employed mercury as the cooling medium. Turning to the effects of tempering upon quenched structures, the author stated that occasionally two varieties of troostite were present. One of these was the normal kind with no crystallographic outline and of irregular growth, termed by him for convenience troostite "A." The other was formed through the breakdown of separate martensite crystallites, retaining, however, the shape of the latter. To this type of constituent he gave the name of troostite "M."

QUENCHED CARBON-STEEL STRUCTURES.

The last paper was that by Mr. B. D. Enlund, "On the Structure of Quenched Carbon Steels." Measurements were carried out by Mr. Enlund in order to determine the influence of annealing on the electrical resistivity and the specific volume of quenched carbon steels. His results showed that some of the γ-iron was preserved at ordinary temperatures after quenching mild and medium steels and, moreover, it was not even necessary to quench the latter at an unusually high temperature to retain some untransformed austenite. He had come to the conclusion, therefore, that even when steels were low in carbon they contained some untransformed γ-iron (austenite) after quenching. His experiments had confirmed the fact that, upon annealing, martensite was transformed into troostite at temperatures ranging from 100 to 200 deg. C., the reaction being most marked at 110 deg. C. His findings also seemed to indicate that the austenite retained after quenching was decomposed into ferrite and cementite at a temperature of approximately 260 deg. C.

Several of the members having expressed to the Chairman their desire to discuss the last two papers together, he called upon them to put forward their observations. In the discussion which followed, allusion was also made to a paper by Mr. Lucas, read in December last before the American Society for Steel Treating.

In opening the discussion, Colonel N. T. Belaiew said the first point of importance raised by Mr. Whiteley was the fact that he distinguished four types of martensite. His details regarding what he called "structureless martensite" were very interesting. Mr. Lucas considered that martensite was always stained by picric acid, whereas Mr. Whiteley mentioned that some parts of the constituent were not etched. Both could not be right. An explanation might perhaps be found in the fact that the chemical composition of the areas not touched was different. Mr. Whiteley showed that the concentration of carbide differed in some of the areas. It was not impossible, therefore, that the areas rich in carbides and in γ-iron were the parts of the martensite which could not be etched, but these areas, apparently, were not martensitic, but austenitic. If this suggestion were wrong, he was still of the opinion that differences in etching were due to differences in chemical composition. The second important point contained in the paper related to the consideration of two types of troostite, named by the author "A" and "M." Mr. Lucas also considered two varieties of troostite; he termed the one "nodular" and the other "flocculent." Mr. Lucas defined the "midrib" of the martensitic needle as that portion which etched more readily than the remainder of the constituent. In one of Mr. Whiteley's microphotographs, this "midrib" could be plainly seen. In conclusion, he wished to draw attention to a statement made by Mr. Whiteley to the effect that no observation had been made during the investigation which would suggest that martensite was other than a solid solution, provided it was agreed that austenite was such, for the two behaved very similarly in several ways. He (the speaker) found some difficulty in entirely agreeing with that view. He still preferred to consider that austenite was a solid solution and that martensite was not.

Professor F. C. Thompson said he considered that martensite was a solid solution; there was good reason to suppose that martensite consisted of a super-saturated solution of carbide in α-iron. Colonel Belaiew had intimated that the needles in acicular martensite were different in composition

from the material from which they separated out and in which they were embedded. That was not a new suggestion. After tempering, the areas represented by the martensitic needles were much freer from carbide than was the material lying between them. Two points in Mr. Whiteley's paper specially appealed to him. One was in connection with the wholehearted acceptance of the twinning theory of martensite. This latter had been put forward by Professors Edwards and Carpenter and was practically the position which Mr. Millington and he himself were compelled to adopt. The other point was that Mr. Whiteley emphasised the fact that the structural changes that took place on quenching were initiated at the surface. Professor Benedicks dealt with that question many years ago. Mr. Whiteley made an observation which he thought new: that the formation of troostite was also a surface phenomenon.

He could not quite agree with the author's explanation in regard to martensitic growth to the effect that the latter had been induced at the corners and edges by the greater stresses produced in those parts during the quench. While agreeing with the result, he thought the explanation of what took place was not that the stress was greater at the surface and edges, but that at the surface and edges the material was freer to deform under the stresses which were present. Mr. Whiteley had done real service in putting forward his definite proof that martensite was formed in quenching at a low temperature. The view was still held, chiefly by our Japanese friends, that the formation of pearlite from austenite took place through the martensitic phase. There was no proof at all that this was the case, and the author's paper showed that the formation of pearlite along these lines was quite impossible.

Professor Thompson then considered Mr. Whiteley's paper in connection with that of Mr. Enlund. In both, the suggestion was made that the change from austenite to troostite or sorbite was very definitely discontinuous. From the point of view of physical and mechanical properties, it would appear that there were definite discontinuities. He had the greatest difficulty in believing that the needles of an acicular martensite structure changed to troostite at a temperature of 95 deg. C. It was a metallographic point; he could not help feeling that the rather dogmatic conclusion to the effect that martensite tempered to troostite at, or around, 100 deg. C. was unjustifiable. Assuming that the breakdown of the solid solution was continuous, there was the possibility of abnormalities being introduced into that continuous change. He thought he could claim, in conjunction with Mr. Whiteley, that there was a series of changes taking place in α-iron when it was heated to comparatively low temperatures (100 deg., 200 deg., 300 deg., or 400 deg. C.). The changes had been confirmed, from the point of view of magnetic properties, by Professor Smith, of Birmingham University. There was very good reason to doubt, for the moment, the conclusion that martensite tempered to troostite at 100 deg. C. He agreed with Mr. Enlund's conclusion that all carbon steels quenched in water in the ordinary way contained some austenite.

Professor S. L. Hoyt expressed the opinion that the X-ray evidence on quenched structures had been rather disappointing. The microscope had been used extensively, and was still being used in connection with the question, but it had not led to definite positive results on what he termed the "fine points." The thermal evidence was valuable, but not conclusive. Professor Hoyt referred to the work by Portevin and Garvin, who found that troostite formed in the neighbourhood of 600 to 650 deg. C., and martensite at 300 deg. C. He had just visited Dr. Hanemann, who, he added, had arrived at a new conception of steel below the Ar 3, 2, 1 line. Dr. Hanemann had found a critical point in pure iron at a temperature of about 600 deg. C., which occurred during quenching. He had also found that martensite, in an ordinary sample of quenched steel, was not a single-phase, but a two-phase material.

Professor W. Campbell, who spoke next, said he could not help being impressed by the fact that even if martensite could be divided into four types, these types were similar. When, however, one spoke of two types of troostite, there was no similarity between them. He referred to the typical troostite produced on quenching, as compared with the so-called troostite obtained on tempering. Microscopy alone could not solve all the difficulties relating to the structure of martensite and troostite; it was necessary to call in the X-ray workers and also those investigating magnetic and electrical conductivity properties.

Mr. A. F. Hallimond said that the papers by Messrs. Whiteley and Enlund together represented a most valuable addition to the description of the microstructure of quenched steels. On the theoretical side, however, he was quite unable to accept the interpretation put forward by Mr. Whiteley. The quenching, though rapid in the early stages, seemed exposed to a risk of delay when the piece floated in the mercury. Both Le Chatelier and Benedicks had found mercury somewhat less efficient than water for this purpose. Mr. Whiteley considered that the facts he recorded were inconsistent with the supersaturation theory, and had revived the idea of a metastable solid solution, in direct conflict with the well-known X-ray results of Westgren, who proved that martensite had the α-lattice. He was compelled to invent a new "transitory form" of iron to account for this solution. After careful reading, he (Mr. Hallimond) had not found any fact which could not be fully explained in terms of the super-saturation theory which he put forward in 1922.* Indeed, some details seemed to exclude the possibility of a solution, and to necessitate the acceptance of Westgren's view that martensite is a colloid suspension of carbon in α-ferrite. Mr. Whiteley's experiments now proved that the carbon was uniformly distributed through the crystals. This condition was foreshadowed in the super-saturation diagram, in which a horizontal line about 600 deg. C., was marked "crystallisation of cementite suspended (in rapid cooling)." The carbon should, therefore, be immobile at 300 deg. C., and would remain suspended in the α-ferrite; this did not alter the nature of the martensite precipitation, which was still correctly described as a labile shower of α-ferrite. He suggested that the critical changes in "missing carbon" on tempering, recorded by Mr. Whiteley in 1917, corresponded with Mr. Enlund's critical points. If that were so, the upper point would be shown by the white-etching martensite equally with austenite, and it would be possible to avoid the conclusion that γ-iron is present in low-carbon quenched steels.

As regarded martensite and troostite, all the structures agreed with the supersaturation theory. Dark-etching martensite formed at a higher temperature, and had a longer cooling range. With medium carbon, the structure was better preserved and etched white. At higher carbon percentages the martensite line passed below Enlund's limit below which austenite was preserved; consequently the shower precipitation was suspended and the early-formed crystallites of α-ferrite (containing suspended carbon) remained in a ground mass of austenite. With more rapid cooling, the martensite line was displaced toward higher temperatures, and all these structures consequently appeared at higher carbon values. The increase in quantity of troostite "A" between a percentage of carbon of 1·50 and eutectoid composition was directly indicated by the stippled area in the supersaturation diagram. Finally, the reconstitution of austenite from martensite at low temperatures might be expected for high-carbon steels with composition near the prolongation of the Ar 3, 2, 1 line. The agreement between the behaviour of a quenched steel and that of a supersaturated solution was, he believed, sufficiently close to render unnecessary the revival of the theory of a metastable transition point.

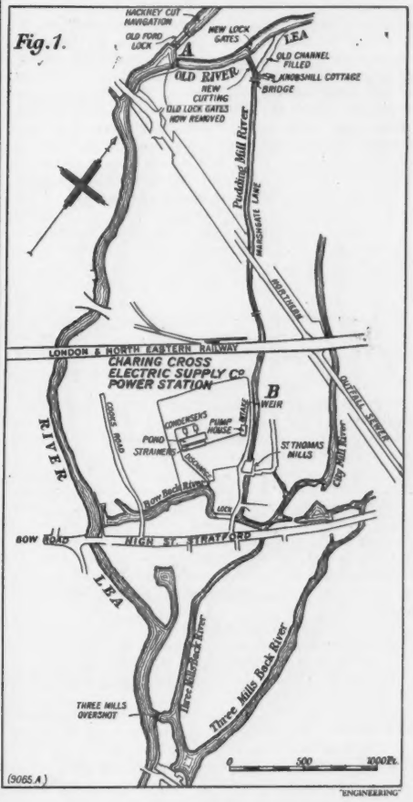
The other papers on the list were taken as read, and the chairman thanked the authors for their contributions. The usual votes of thanks to the Institution of Civil Engineers for the accommodation which they had kindly afforded for the meeting, and to the chairman, concluded the proceedings.

* See ENGINEERING, vol. cxiii, pages 628 and 767.

RECONSTRUCTION OF THE BOW POWER STATION.

CLOSE by the Bow power station of the Charing Cross Electricity Supply Co., Limited, is an old Watt engine, erected about 1815, which is still in occasional operation. Inside the power station are two splendid Sulzer engines, each coupled to a 4,000-kw. generator. These were erected near the beginning of the present century and then represented about the acme of reciprocating steam-engine practice. To-day they are utterly obsolete and worthless, save for scrap, whilst, as already mentioned, the old Watt engine close by is still doing useful work. It would be difficult to find a more striking illustration of the difference in the conditions which to-day confront the investor in power plant from those with which his great grandfather had to deal. The obsolescence factor now looms large; then it was of relatively little importance. The remodelling of the Bow power station was commenced in 1914, but, owing to the war, little progress was possible until 1919. By that date, the necessity for an entire reconstruction of the station had become emphasised, and the work has since been steadily pursued. The whole of the old

Fig. 1.



reciprocating plant has now been shut down and most of it removed, and the two survivors will remain in place only until the space they occupy is needed for additional steam-turbine generators. The plant now in use consists of two 6,000 kw. units erected in 1921 and two later 12,500 kw. sets which were supplied in 1922–23 by Fraser and Chalmers Engineering Works. The English Electric Company, Limited, are now about to instal a 16,000-kw. unit, the erection of which is being considerably hampered by the heavy work of breaking up and removing the massive concrete foundations of the reciprocating set which previously occupied the site. The enormous advance made in power-station economy during the past few years is strikingly shown by a comparison of the steam rates of the turbines successively installed. The first of these was a 6,000-kw. unit and took 14·9 lb. per kw.-hour at 90 per cent. power factor. Its successor of the same output had a steam-rate of 13·7 lb., whilst, of the two 12,500-kw. units now in place, the first took, on test, 10·72 lb. per kw.-hour and the second 10·70. The 16,000-kw. unit at present in course of construction, has a guaranteed steam rate of 10·03 lb. per kw.-hour. All the above steam rates refer to a 90 per cent. power factor. Perhaps the march of progress is even better shown by the improvement in the overall thermal efficiency of the station during

the last four years, the figures for which are given below :—

Year.	B.Th.U. per kw.-hour delivered to Feeders.	Thermal Efficiency. (Coal to Electricity.)
1921	38,840	8·78 per cent.
1922	36,884	9·23 „
1923	28,791	11·86 „
1924	23,340	14·6 „

The improvement still continues, and the station is being operated to-day with a thermal efficiency of 16½ per cent., which is the more satisfactory in that the Bow power station has an exceptionally large variation in its load, the minimum falling at times to about one-twelfth of the maximum. The coal consumption in 1914 was 4·8 lb. per kw. delivered to the feeders, and in 1924 it was 2·42 lb.

Part of the gain in efficiency has been due to advances in turbine design, but part also is due to an increase in the pressure and temperature of the steam. The old boiler plant was designed for a working pressure of 175 lb. per square inch, and a total steam temperature of 540 deg. F. Its most striking features were the three vertical Hornsby boilers installed by Mr. W. H. Patchell. These, at the time of their erection, some thirty years ago, were the largest in the world, each having an evaporative capacity of 50,000 lb. per hour. In the height of the furnace, and in other details, they anticipated modern practice, and, indeed, per cubic foot of space occupied, had as large an output as the latest steam generators. The new boilers, of which seven are of the Babcock and Wilcox C.T.M. type, and two of Messrs. Vickers-Spearing's manufacture, are designed for a working pressure of 265 lb. per square inch, and a total temperature of 650 deg. F. The total heat in the steam supplied is, therefore, about 1,349 B.Th.U., as against 1,298 B.Th.U. under the old conditions, and the steam being at a higher temperature, the heat has, of course, a great availability. Superheaters and economisers are fitted to each boiler, and there is, in addition, an elaborate system of feed heating, of which we give details later on.

Still more important changes have been made in the supply of the condensing water. The old Sulzer sets were operated with cooling towers, which, in view of the incapacity of the reciprocator to utilise a good vacuum, were perfectly satisfactory, but their continuance with modern steam-turbine plant would have involved a very material increase in the fuel consumption per kilowatt generated. Taking as standard of reference the steam conditions in front of the stop valve, then, with a 27-in. vacuum, the isentropic heat drop would be 397·5 B.Th.U.; with a 28-in. vacuum, it would be 418·4 B.Th.U., and with a 29-in. vacuum 452·9 B.Th.U. In very cold weather, moreover, a vacuum of 29¼ in. is obtainable, for which the corresponding isentropic heat drop is nearly 470 B.Th.U. At present fuel prices, the advantage of a high vacuum is, it will be seen, very substantial, and well worth paying for.

Whilst the advantage of aiming at the highest practicable vacuum were sufficiently obvious, it was not easy to see how the requisite large supply of cooling water was to be obtained. The station is situated, it is true, in marshland, and has waterways, of a kind, along two of its boundaries (see Fig. 1 on page 635). Both communicate with the Lea, but the one was canalised and the other, the Pudding-Mill Creek, was so silted up, that, save at times of flood, or at high-tide, it was merely an offensive ditch. The plan ultimately decided on, nevertheless, utilised this Creek by deepening it, and diverting into it additional water from the Lea. This was effected by constructing a new set of lock gates at the position shown in Fig. 1, those at A being abandoned. A view of these new gates is reproduced in Fig. 2. A dam was also constructed across the Creek at the site marked B, which is just below the intake to the power station. By these measures, a supply of condensing water has been secured, which will be sufficient even should the ultimate capacity of the station be raised to 85,000 kw.

The water discharged from the condensers is not turned back into the Pudding-Mill Creek, since the flow here sometimes ceases at high-tide, but is delivered into the Bow Back River, another tributary of the Lea which forms one of the boundaries to the station site. This waterway communicates, it is true, with the Pudding-Mill Creek, but only by a route some mile and a-half long (see Fig. 1). At times of low tide, the circulating water is all fresh water, but in dry weather, for a certain interval at high tide, the flow ceases and the mile and a-half of waterway between the condensing water discharge and the intake then serves as a gigantic cooling tank.

The intake from the creek is protected by a fender, of which the lower edge is carried well below the minimum water level. This fender excludes all surface flotsam, and behind it are two iron-bar screens, which protect the intakes from all other bulky matter

RECONSTRUCTION OF THE BOW POWER STATION.

FIG. 2. NEW LOCK GATES ON THE RIVER LEA.

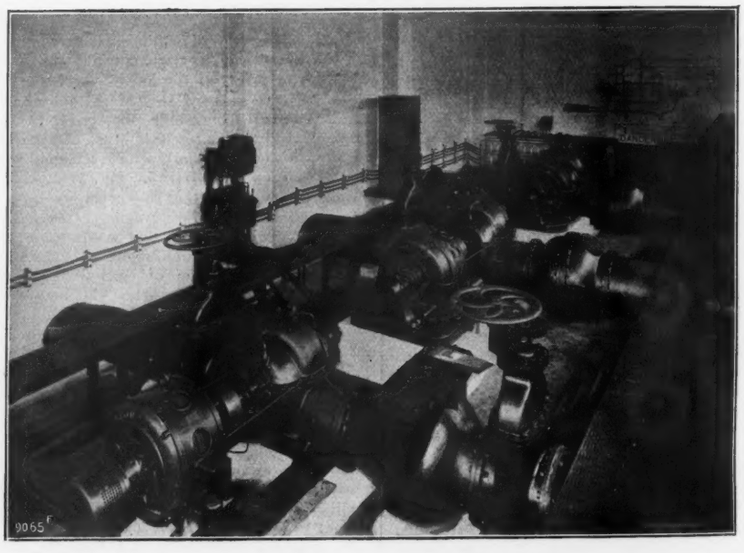


FIG. 3. ELECTRICALLY-DRIVEN PUMPING PLANT.

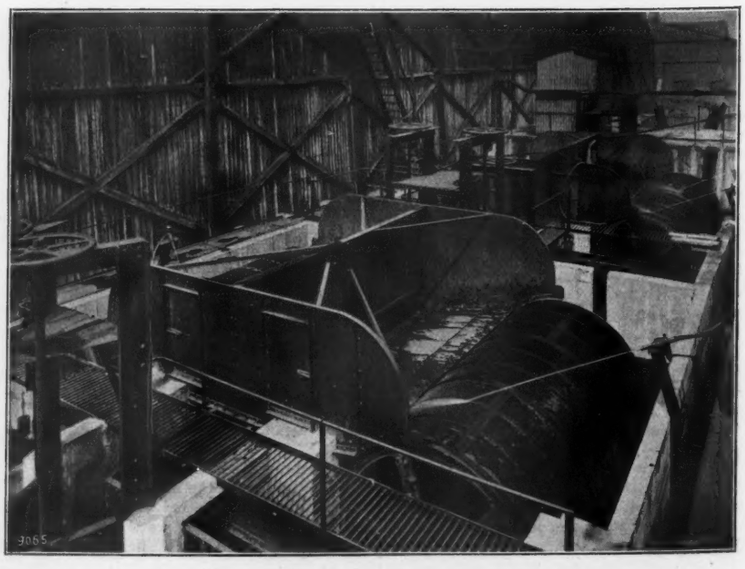


FIG. 4. REVOLVING STRAINERS SHOWING CLEANSING JETS.

entrained in the flow. Gear is provided for lifting these screens for cleansing and examination. The inlets consist of four 27-in. pipes leading into a 48-in. 'bus pipe, which conveys the water into the pumping station. The floor of this is below the lowest water level in the creek, with the result that the centrifugal pumps here installed work drowned and never require priming. There are four of these pumps, all supplied by Messrs. W. H. Allen Sons and Co., Limited, Three are driven by alternating-current motors, deriving their supply of current from the main 'bus-bars. The fourth has a direct-current motor coupled up to the 'bus-bars of two continuous-current generators, which, in normal working, supply the current required for the station auxiliaries. The interior of the pump house is illustrated in Fig. 3.

The pumps deliver the water through revolving strainers into tanks, which had been constructed for use with the old cooling towers. A view of one of these strainers is reproduced in Fig. 4. They are kept clean by powerful jets of water played over their surfaces by nozzles which are traversed to and fro by a rope drive. These have been found very effective, it being but very seldom that any hand cleaning has to be resorted to. The strainers consist of perforated steel drums, and the water passes in radially through the perforations and escapes at one end, whence it passes to the circulating pump suctions. The whole of the circulating water is chlorinated before admission to the condensers. This has been found to be an effective preventive against the fouling of the tubes. Circulating water temperatures are now so low that, lacking this precaution, there is liable to be trouble from algæ and other organic growths.

The conditions at the station were not favourable for progressive feed heating, and other means have accordingly been resorted to. These are illustrated diagrammatically in Fig. 5. The vacuum in the main turbines being 29 in., the condensate is withdrawn at a temperature of about 79 deg. F., and is all passed into the intermediate tank shown. Since a temperature of about 150 deg. F. was desired in the hot well, it was decided to use the condensate from the main turbines as condensing water for the two 1,000-kw. "house-service" units already mentioned. These, which were supplied by Messrs. W. H. Allen Sons and Co., Limited, are geared to direct-current generators and are provided with jet condensers. With the system described, these two turbines may be regarded as "extraction turbines," as their main function is to act as feed heaters. They have, of course, the advantage over live-steam feed heaters that a substantial amount of energy is extracted from the steam before it passes to the jet condensers which serve as feed heaters. The condensate from these is delivered to the hot well at about 150 deg. F., and from this it is pumped to head tanks on the top of the bunker floor. The exhaust steam from these pumps, and from the feed pumps, is turned into this tank, the temperature of which is maintained at about 200 deg. F.

It should be further added that the water on the way to the head tank is also passed through a couple of spray coolers. Here it meets with and condenses the steam generated in the evaporators, from which the make-up feed is derived. These evaporators take their supply from a well, and the water is passed through a softener before admission to the pumps; the evaporation is effected by live steam. With this arrangement no raw water enters the boilers, the whole of the feed, both condensate and "make up," being distilled. From the head tank, the water passes through the feed pumps to the economisers, where it is raised to a temperature of 265 deg. F., at which it enters the boilers.

An elaborate system of distant-reading thermometers is provided. The indicators for the hot-well and head-tank thermometers are located in the switchboard gallery and the temperatures are regulated by the switchboard staff, whilst the indicators recording the water and gas temperatures before and after the economisers are fixed in the boiler instrument room. The gas temperature, as it leaves the economisers, averages about 365 deg. F.

In the boiler instrument room are also the steam-flow indicators and integrating instruments, and the draught indicator, which gives readings below grate, above grate, and at the base of the stack. The coal is measured by a Lea coal meter. This is a volumetric meter, but its readings are checked daily and it is found to be very accurate. Lea recorders are also provided for measuring the condensate from the turbines, and the records for each shift are systematically plotted on the system originated by Mr. R. H. Parsons when electrical engineer for the City of Edmonton. This method has been described several times in our columns. Coal and water are plotted against output and Mr. Parsons observed that the plot was well represented by a straight line. In this way a comparison was, for the first time, made possible between the work of different shifts. If on any shift the plotted point is notably above the Parsons line for the station, it affords a sure indication of some defect in need of correction. A couple of the Parsons lines for one month at the Bow station are reproduced in Fig. 6. The upper line was obtained in March, 1924, and the lower in the corresponding month this year. The improvement is notable.

The boilers each have an evaporative capacity of 55,000 lb. per hour. Each has its own economiser and superheater. CO_2 indicators are provided and both the total flow of water into the boiler and the amount of make-up are metered. The ashes are discharged over the grate into a large hopper which is periodically emptied into a crusher. The latter reduces all ash and clinker

Fig. 5.

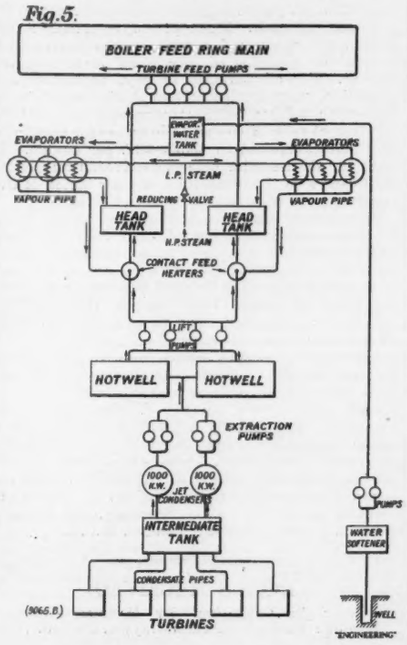
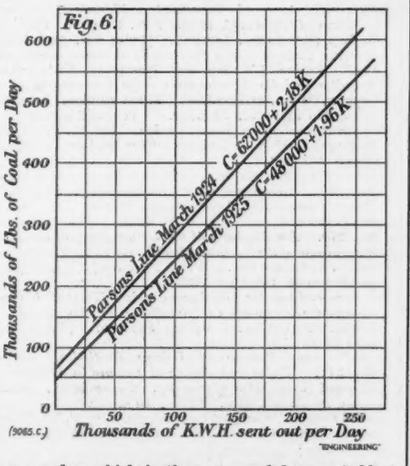


Fig. 6.



to a powder, which is then removed by an air blast. Both the large turbines are of the impulse type. Each is fitted with a stop valve temperature indicator, a vacuum recorder, and a circulating water inlet and discharge temperature recorder. The neutral from the generators is earthed through a carbon resistance designed for 500 amperes at 6,000 volts. There is room in the existing engine room for two more 15,000 kw. sets, which would bring up the total station capacity to 85,000 kw.

The work of station reconstruction has included the replacement of the old switchgear with switches of much greater capacity. The station auxiliaries are direct-current driven and, as already explained, this current is, in normal working, supplied by two special 1,000 kw. turbo generators. To guard against the possibility of a breakdown, two independent sets of auxiliary 'bus-bars are provided, one set of which is fed from the generators aforesaid and the other from a motor generator deriving its current from the main station 'bus-bars. The cost of the new plant has been about 15*l.* per kilowatt, a figure which will be reduced to about 13*l.* per kilowatt when, and if, the station is enlarged to the 85,000 kw. capacity contemplated as an ultimate possibility.

Views showing the interior of the engine room and of the boiler room are reproduced in Figs. 7 and 8, on page 640.

The consulting engineers for the whole of the work were Messrs. Highfield and Roger Smith.

LETTERS TO THE EDITOR.

THE ACCIDENT TO THE R 33.

TO THE EDITOR OF ENGINEERING.

SIR,—With regard to the letter in your issue of the 15th inst. from Lieutenant-Colonel Lockwood Marsh, O.B.E., may I say that I adhere *in toto* to the personal views which (writing as a former airship officer with considerable mooring experience) I originally expressed.

Since on this matter, as on some former ones, I am unable to accept the majority of the ideas which Lieutenant-Colonel Lockwood Marsh puts forward, I suggest (and have little doubt that he, as a barrister, will concur), that we leave the decision on the points relevant to issue to the Airship Co-ordinating Committee.

I am, Sir, yours faithfully,
P. L. TEED, Major (late R.A.F.).
Hayesden House, near Tonbridge, Kent.
May 19, 1925.

THE USE OF A DIAMOND PYRAMID FOR HARDNESS TESTING.

TO THE EDITOR OF ENGINEERING.

SIR,—We should be much indebted to you if you would allow us to make some reply through your columns to points raised in the discussion on our paper, on "The Use of a Diamond Pyramid for Hardness Testing," which, owing to lack of time, it was not possible, verbally, to make at the meeting of the Iron and Steel Institute itself last week.

We have the Secretary's permission, pending publication of the official proceedings, to deal in this manner with the various points raised.

We wish, in the first place, to thank Sir Robert Hadfield for his suggestions, which we will certainly follow up by taking the earliest opportunity of submitting copies of the paper to Dr. Unwin and to the Committee for the Standardisation of Hardness Numerals.

In dealing with the various subjects raised in discussion, it is proposed to group them under the following headings:—(1) Principle and method; (2) The use and form of the diamond; (3) The shape of impression.

(1) *Principle and Method.*—With reference to Professor Turner's remarks regarding the difficulty of measuring small scratches and small impressions obtained by the Brinell ball method, it may be of interest to note that, with the standard machine employed for these tests, no difficulty is presented in measuring the diamond impressions accurately to 0·002 mm., which, on the hardest of steels, amounts to an error of about 1·5 per cent.

In reply to Dr. Hoyt and Mr. Axel Hultgren, we feel, as Sir Robert Hadfield clearly pointed out, that there is a real need for an improvement in the Brinell ball test, which fails to give comparable results owing to the occurrence of certain variables. In attempting to improve such tests, while bearing in mind the desirability of avoiding the introduction of a new scale, it is unquestionably advisable to remove as many sources of variation as possible, and this we have endeavoured to do by the use of a diamond pyramid in conjunction with a machine which ensures constant conditions of application and duration of load. From the results obtained, there appears to be every reason for assuming that the diamond-pyramid numerals are identical with those which would be obtained with constant-sized impressions obtained with a polished diamond ball.

Referring to the remarks made by Dr. Hoyt and Mr. de Forest concerning the Rockwell machine, we feel that it is not possible to compare the two methods as they are based on entirely different principles.

With regard to Mr. Hugh O'Neill's remarks concerning the somewhat higher numerals obtained with the diamond pyramid at very low loads on copper, and certain other soft materials, it may be stated that we had observed this effect and found it to be caused by the surface-hardening produced in preparing the specimen for test. If the specimen be suitably etched before testing, the numerals will be found to be practically identical at both low and high loads. This very low load method of testing has been found to be quite useful in investigating

certain commercial articles, the extreme surfaces of which have been variously hardened by polishing, grinding, &c.

(2) *The Use and Form of the Diamond.*—We agree with the remarks made by Professor Louis concerning the value of the natural pyramidal point of a diamond and have carried out an investigation on this subject.*

The pyramids referred to in the present paper were, in every case, cut with the natural point as a foundation, and it is found that, by so doing, the final pyramid can be finished to a most excellent polish. In using pyramids so cut, there appears to be no indication whatever of splitting along the cleavage planes. In the total absence of abuse, we are of opinion that the life of a diamond is almost indefinite. The initial cost of these diamonds is by no means excessive, and the re-cutting of a damaged stone is generally a simple matter.

In reply to Mr. Axel Hultgren, it may be stated quite definitely that although in the initial stages the accurate cutting of the diamond presented many obstacles, after considerable experimental work these difficulties have been entirely overcome.

Experiments have been carried out with sapphire balls, but, in addition to the disadvantage attendant upon the use of a ball, it was found that they crushed very easily even under light loads.

For accurate research work it is, of course, desirable to have a good polish on the work tested, but the polishing for ordinary routine testing presents no difficulties, emery cloth giving a sufficiently good finish.

No experiments were made with a pyramid of an angle smaller than 120 deg., but it is of interest to note that, in experiments with cones, Mr. Hankins† observed that the smaller angles of cone were more liable to inconsistencies than were the larger, and it is reasonable to expect analogous results from pyramids. Furthermore, acute angles would probably be somewhat fragile.

(3) *The Shape of Impression.*—Attention was drawn by Mr. Hugh O'Neill to the similarity in bulge effect between the diamond pyramid impressions and the prism impressions obtained by Dr. Haigh‡ with regard to materials which are markedly capable of being further hardened by overstrain, such as annealed copper, austenitic steels, &c. We have observed this characteristic with the diamond pyramid, and find it to be useful in differentiating between materials of this class and those which are less prone to further hardening by cold working.

The steel ball, of course, produces similar results, as can be proved by sectioning an impression, but as the impression, in plan, is always a circle, the bulge effect is not always obvious, but simply goes to vitiate the definite dimensions of the impression. With the square impressions, the corners are unaffected, and it will therefore be seen that the correct method is to take the measurement across the diagonals.

Trusting that we have not trespassed at too great length on your space, we are,

Yours faithfully,
R. L. SMITH,
G. E. SANDLAND.

Vickers House, Broadway, Westminster.
May 11, 1925.

THE CIRRUS AERO ENGINE: ADDENDUM.—The Aircraft Disposal Company, Limited, Regent House, Kingsway W.C.2, inform us that the Cirrus aero engine, which we illustrated and described in our issue of May 8, on page 572, has now successfully completed the Air Ministry 100-hour type test. The engine ran for 10 hours on a Heenan and Froude brake, developing 54-h.p. at 1,800 r.p.m.; for 50 hours on a calibrated propeller, developing 54·5-h.p., at 1,820 r.p.m.; and for 39 hours on the brake at the first-mentioned speed and power. It was then run for an hour on the brake at full throttle, and at the normal speed of 1,800 r.p.m., developing 61-h.p. during this period and afterwards for one hour each at high speed and at high power and speed. The high-speed test was run at 2,080 r.p.m., and the high-power and speed test at 1,980 r.p.m.; the output during the last test was 68·25-h.p. For the whole period of the test, the average petrol consumption worked out at 0·627 pint per brake horse-power per hour, the corresponding figure for the lubricating oil being 0·0134 pint. The maximum oil pressure recorded was 9 lb. per square inch, and the maximum temperature of the oil in the sump was 54 deg. C.; the average figures for the oil pressure and sump temperature were 7·24 lb. per square inch, and 43·2 deg. C., respectively.

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* "An accurate method of determining the hardness of metals with particular reference to those of a high degree of hardness." Proceedings of the Institution of Mechanical Engineers, 1922. Vol. 1.

† "Report on the effects of adhesion between the indenting tool and the material in ball and cone indentation hardness tests." Proceedings of the Institution of Mechanical Engineers, April, 1925.

‡ "Prism hardness: A new test for hardness." Proceedings of the Institution of Mechanical Engineers, October, 1920.

SHORT-SERVICE OFFICERS FOR THE ROYAL AIR FORCE.

We are informed by the Air Ministry that, during the next three months, the Royal Air Force is prepared to accept about 100 officers for flying duties under the Short-Service Commission Scheme. Candidates, who should be of thoroughly good education and physique, but who need not have had any previous flying experience, must not be less than 18 and not more than 25 years of age at the time of entry. Those selected, after passing the standard R.A.F. medical examination, will be gazetted as pilot officers on probation. The probationary period is six months, after which, subject to satisfactory progress, officers are confirmed in rank. Short-service commissions are granted for five years' service on the Active List, followed by a period of four years' service on the Reserve. For all purposes of pay, allowances and promotion, short-service officers receive equal treatment with officers holding permanent commissions. The present rates of pay and allowances for unmarried pilot officers amount to about 450*l.* per annum. In addition, short-service officers receive, on transfer to the Reserve on the completion of their period of five years' active service list, a gratuity of 375*l.*

Pilot officers will be posted to one of the Royal Air Force flying training schools, where they will undergo a course of training in aviation and in aeronautical and technical subjects for a period of a year. At the end of this period they will be posted to Air Force squadrons for duty. Pilot officers, provided they qualify for promotion, will be promoted to flying officers, with increased rates of pay, after completing not less than 18 months' service from the date of being gazetted as pilot officers. Arrangements have also been made for all officers, who desire it, to receive special tuition from the R.A.F. education officers, who have been recently appointed, to equip themselves for civil life against the time when their period of service terminates. These educational facilities are being gradually extended. Application forms and copies of the detailed regulations can be obtained by applying in writing to the Secretary, Air Ministry, Adastral House, Kingsway, London, W.C. 2.

BOOKS RECEIVED.

The Case for Capitalism. By HARTLEY WITHERS. London: Eveleigh Nash and Grayson, Limited. [Price 2*s.* 6*d.*]

Kelly's Directory of Merchants, Manufacturers and Shippers of the World, 1925. Vols. 1 *and* 2. London: Kelly's Directories, Limited. [Price 64*s.* post free.]

Conférence Internationale des Grands Réseaux Electriques, 1923. Paris: L'Union des Syndicats d'Electricité.

Hydraulics and its Applications. By PROFESSOR A. H. GIBSON, D.Sc., M.Inst.C.E. Third edition. London: Constable and Co., Limited. [Price 24*s.* net.]

The Resistance of Express Trains. By C. F. DENDY MARSHALL, M.A. London: The Railway Engineer. [Price 20*s.* net.]

United States Bureau of Standards. Technologic Paper, No. 269. *Specification for Constructing and Operating Heat-Transmission Apparatus for Testing Heat-Insulating Value of Fabrics.* By P. D. SALE. [Price 10 cents.] No. 270. *An Analysis of the Deformation of the Mooring Spindle of the "Shenandoah."* By L. B. TUCKERMAN and C. S. AITCHISON. [Price 10 cents.] Washington: Government Printing Office.

Die Andwendung der Gleichung der drei Moments (Clapeyronschen Gleichung) im Schiffbau. By P. A. H. LORENTZ. Berlin: Julius Springer. [Price 4·50 gold marks.]

United States Bureau of Labour Statistics. Bulletin No. 377. *Wages and Hours of Labour in Woollen and Worsted Goods Manufacturing.* Washington: Government Printing Office. [Price 10 cents.]

Cost of Freight Transport by Railway. By F. W. ROGERSON. Liverpool: F. W. Rogerson. [Price 4*s.* 4*d.* post free.]

United States Bureau of Standards. Scientific Papers. No. 501. *Specific Heat of Superheated Ammonia Vapour.* By N. S. OSBORNE AND OTHERS. Washington: Government Printing Office. [Price 15 cents.]

Illuminating Engineering. Edited by FRANCIS E. CADY and HENRY B. DATES. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 25*s.* net.]

Technical Mechanics, Statics, Kinematics, Kinetics. By EDWARD R. MAURER and RAYMOND J. ROARK. Fifth edition, rewritten. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 17*s.* 6*d.* net.]

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W.1, announces that a firm in Sarajevo, Jugo-Slavia, invites tenders from British manufacturers for the supply of 1,000 railway wagon-wheel tyres rolled from Siemens-Martin steel.—The South African Railways and Harbours Administration invite tenders, until July 6, covering delivery f.o.r. in bond at certain South African ports, for the supply of 322,810 lb. of round copper bars for firebox stays, varying in diameter from ¼ in. to 2½ in.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—The latest official returns up to and including last month (April) relating to South Yorkshire coal traffic *via* Hull, indicate a certain measure of improvement in some of the overseas markets. For the four months under review, as compared with the corresponding period last year, more business was done with South America, Denmark, Iceland, Italy, and Norway. The most substantial improvements were in the cases of Iceland and Norway, a rather remarkable feature being that Iceland took a bigger tonnage than Germany. This gross improvement, however, is more than counterbalanced by a further falling off in some of the principal Continental markets. The total sent to Germany for the four months was less than one-sixth that of the previous year, while France took little more than half. Sales to Holland and Sweden were also considerably down. Aggregate exports were over 200,000 tons less than during the first four months in 1924, though the total for April was only slightly below that for the same months last year.

Iron and Steel.—The position shows evidence of improvement in some of the lighter sections, but very little movement in any description of basic material. Inquiries are in circulation for basic steel, but they are mostly at prices at which local works cannot produce profitably, and most business is being lost on this account. Conditions are very much the same in pig iron and scrap. Where possible, the tendency is to accept special rates for prompt sales, though the rigid character of overhead charges prevents the prosecution of such a policy beyond a certain point. There is no improvement in Lincolnshire's basic-steel trade. Machinery makers continue to benefit from British colliery enterprise. More shafts are being sunk and seams extended in this and adjoining areas, but the unsatisfactory character of export bookings necessitates increased sums being placed to reserve by colliery undertakings against the expense incurred from working extensions. Wagons are on order for the near East. There is a steady improvement in outputs of files, saws, and other light tools. A moderate business is being done with the Colonies in farm tools.

South-Yorkshire Coal Trade.—The position displays no tendency to improve, and, so far as the export trade is concerned, it is unsatisfactory. In washed sorts, the home demand is fairly active, but overseas requirements continue to disappoint. Steam coal finds a moderate outlet on inland account, while the shipping position remains unaltered. Cobbles and nuts are hard to dispose of, but slacks maintain recent improvement. There is o ly a limited amount of business passing in house coal, and that is confined to the better grades. A weakness is apparent in foundry and furnace coke, while gas cokes are on the same level. Quotations:—Best branch handpicked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 27*s.*; Derbyshire best brights, 26*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* 6*d.* to 25*s.* 6*d.*; Derbyshire best large nuts, 18*s.* to 22*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; Rough slacks, 10*s.* to 12*s.* 6*d.*; Nutty slacks, 8*s.* 6*d.* to 10*s.*; Smalls, 3*s.* to 5*s.* 6*d.*

ESCALATOR FOR LIVERPOOL STREET.—A third escalator at the Liverpool-street station of the Central London Railway was put into service during the week to supplement the two existing escalators now handling the traffic to and from the main line station of the London and North Eastern Railway Company. The new moving stairway will be of "comb" type, and, being reversible, will be worked in the downward direction in the morning and upward at night, thus speeding-up the exchange between the tube and main-line stations by clearing more rapidly the train loads as they arrive from both these routes. A further improvement is the provision of additional passageways at the foot of the escalators leading to the platforms of the Central London Railway. The booking accommodation is also being entirely remodelled, the passimeter system being introduced.

THE AUGSBURG MEETING OF THE VEREIN DEUTSCHER INGENIEURE.—The city of Augsburg participated in the exhibition held at Augsburg in connection with the annual meeting of the German engineers, which was opened in the former Free Town of the Old Empire on May 10. The city exhibited a collection of models and drawings, and also of designs of engineering structures and works, mainly concerning hydraulic construction, utilisation of water power, canalisation and gas supply. According to tradition, water mills were in operation at Augsburg as early as the eleventh century. There is documentary evidence of the operation of six mills in the year 1276. By 1761, the number had risen to over sixty, there being mills for diamond and glass grinding, powder mills, oil, flour, tobacco and spice mills, as well as textile and saw mills. The situation of the town favoured this development; the town lies in the fork between the River Lech and its tributary, the Wertach, which are interconnected by many natural and artificial channels. A great many interesting models of water-power machinery, some dating from the fifteenth to the eighteenth century, illustrated both the technical practice and the climatic conditions of the time. The technical trade schools, which train artisans and enable them to qualify as masters, were likewise represented by specimens of their handicraft.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues on a very disappointing scale, but the market is steadier, and hope is expressed that transactions on both home and export account will expand. Supply is not over plentiful, makers' stocks being low, but orders continue to be keenly sought after, and buyers report that they can cover their requirements at a little below recognised market figures. No. 1 is 81*s.*; No. 3 g.m.b., 76*s.*; No. 4 foundry, 75*s.*; and No. 4 forge, 74*s.*

Hematite.—East Coast hematite is very plentiful, and producers, in their anxiety to liquidate the heavy accumulations at their works, are cutting quotations. There are a few Continental inquiries in the market, but sales both on home and overseas account are not easily arranged. No. 1 is 81*s.* 6*d.*; and Nos. 1, 2 and 3 are 81*s.*

Foreign Ore.—Sellers of important ore experience as much difficulty as ever in putting through business, and in the continued absence of transactions, market rates are still based nominally on best rubio at 22*s.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke is in ample supply, notwithstanding recent considerable curtailment of output, and good medium qualities are offered freely at 22*s.* 6*d.* delivered to local users.

Manufactured Iron and Steel.—There is not a great deal moving in finished iron, and steel, but in one or two branches inquiry shows improvement. Fairly good sales of constructional steel and of railway material are reported, and shipbuilding requisites promise to be in better demand. Common iron bars are 11*l.* 12*s.* 6*d.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.*; steel billets (medium), 8*l.* 15*s.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 8*l.* 15*s.* to 8*l.* 17*s.* 6*d.*; steel angles, 8*l.* 5*s.* to 8*l.* 10*s.*; steel joists, 8*l.* 5*s.* to 8*l.* 10*s.*; heavy steel rails, 8*l.* 10*s.*; black sheets, 11*l.* 10*s.*; and galvanised corrugated sheets, 16*s.* 15*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—During the past week rather a better feeling has been noticeable in the Scottish steel trade, but it is still difficult to get that feeling translated into actual business, which is the thing which really counts. Buyers keep holding back, and only specify for their most immediate requirements. When these form a good tonnage very keen prices can be secured, but some buyers have a firm conviction that they will yet be able to place forward lots at prices much below to-day's level. These are the men of an optimistic turn of mind because it is difficult to see how producers can reduce much further and still live. The inquiry for plates and sections is very poor all round. Steel sheet makers report a little more business this week, but only in a few instances can much distance ahead be seen. Galvanised sorts continue in good demand for export, and makers have a fairly good tonnage booked. The following are the prices current:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 8*l.* 17*s.* 6*d.* per ton; sections, 8*l.* 7*s.* 6*d.* per ton; and sheets, $\frac{1}{16}$ to $\frac{1}{4}$ in., 10*l.* 5*s.* to 10*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—Little change can be noted in connection with the malleable-iron trade of the West of Scotland this week. The demand is said to be a shade better, but a very decided improvement will be necessary before the trade nears anything approaching normal conditions. In the steel re-rolling branch there has also been little change, and severe competition with keen prices is very general. The current price of "Crown" bars is 11*l.* 12*s.* 6*d.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—A weak tone continues to characterise the Scottish pig-iron trade, and prospects do not show any sign of improvement. Heavy stocks are general and the demand is as poor as ever. Prices are nominally unchanged and are as follow:—Hematite, 4*l.* 10*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 8*s.* per ton, and No. 3, 4*l.* 6*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 16, only amounted to 318 tons. Of the total, 135 tons went overseas and 183 tons went coastwise. For the corresponding week of last year the figures were 756 tons foreign and 152 tons coastwise, making a total shipment of 908 tons.

Important Contract.—Sir William Arrol and Co., Limited, Glasgow, have just received an order from the L.M. and S. Railway for large additions in connection with the reorganisation of the locomotive works at Crewe. The order is for the steel buildings erected complete, and it also includes the overhead travelling cranes in which the firm specialises. This order, coupled with the other contracts recently secured, will keep the works fully occupied till about the end of this year.

Shipbuilding.—The Fairfield Shipbuilding and Engineering Co., Limited, Glasgow, have received an order from the Liverpool and North Wales Steamship Co., Limited, for a twin-screw turbine propelled passenger steamer. This vessel will be specially designed for the summer and excursion services which the company give between Liverpool, Llandudno and the Menai Straits. She will be 320 ft. in length between the perpendiculars, 44 ft. in moulded breadth, and 31 ft. in moulded depth.—The Burntisland Shipbuilding Co., Limited, have secured an order for a steamer of about 800 tons deadweight for the Brussels Steamship Co. Limited, London.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Ship Repairing Contracts.—In open competition with other United Kingdom and Bristol Channel ship repairing concerns, the Cardiff Channel Dry Docks and Pontoon Company, Limited, have secured a couple of contracts to repair extensive bottom damage suffered by the Cardiff steamers Pilton and Glenaster. In each case the work will take about three weeks and will necessitate dealing with a large number of bottom plates, besides internal work. The Pilton, of 5,100 tons d.w., owned by Messrs. W. J. Tatem, Limited, was blown ashore at Sully, between Cardiff and Barry, in December last, and was recently refloated by Mr. J. Hindmarsh, M.Sc., managing director of the Cornish Salvage Company (1918), Limited, while the Glenaster, 5,300 tons, owned by the Aster Shipping Company, Limited, Cardiff, stranded on the west coast of Africa a couple of months back.

The Coal Trade.—New business in the coal trade is quiet at the moment, but the better descriptions of large coal are well booked up for shipment this side of the holidays, and colliery salesmen in consequence are able to maintain prices. Dry large and bituminous coals, however, are excessive and irregular in price, while smalls, too, are readily available at figures governed by individual circumstances. Shipments of coal as cargo from South Wales last week amounted to 461,030 tons, compared with 457,600 tons in the preceding week. Of last week's total 257,930 tons were exported from Cardiff, 93,010 tons from Newport, 69,220 tons from Swansea, 33,500 tons from Port Talbot, and 7,370 tons from Llanelly. Of the total 56,430 tons were despatched to Algeria, 29,850 tons to Brazil, 21,500 tons to Canada, 39,980 tons to Egypt, 91,900 tons to France, 60,280 tons to Italy, and 34,780 tons to Spain.

Iron and Steel Trades.—It is reported that the Richard Thomas group have secured a contract to supply half a million boxes of Welsh tin plates at 19*s.* 9*d.* against the 20*s.* 6*d.* middle price ruling since the stabilisation scheme fell through. This report has caused some surprise in view of the high cost of production. Generally the outlook is regarded as more hopeful, some fairly good orders having been placed from South America and the Continent. Shipments of iron and steel goods last week totalled 18,106 tons compared with 13,076 tons in the previous week. Exports of tinplates and terneplates totalled 10,055 tons against 7,281 tons, blackplates and sheets 1,329 tons against 1,330 tons, galvanised sheets 5,168 tons against 3,860 tons, and other iron and steel goods 1,554 tons against 605 tons.

THE BRITISH ENGINEERS' ASSOCIATION.—At the Thirteenth Annual General Meeting of the British Engineers' Association, held at the Hotel Victoria, Northumberland-avenue, London, W.C.2, on May 14, Mr. H. J. Ward, of Messrs. J. and E. Hall, Limited, of Dartford, was elected President in succession to Sir Ernest W. Petter, the retiring President.

SEACOMBE FERRY STAGE.—The new 48-ft. long ferries stage at Seacombe, Cheshire, has now been completed at a total cost of 60,000*l.*, and it replaces the stage built on the same site in 1878. The whole weighs approximately 3,000 tons, and features of the construction are the precautions taken to prevent destructive action by sea water. Both the internal and external surfaces of the pontoons and girders of the new pier have been coated with solution and enamel supplied by Messrs. Wailes Dove Bitumastic, Limited.

TRANSPORT OF 48-TON STATOR.—Recently the London Midland and Scottish Railway Company successfully conveyed a 48-ton stator, designed for the 20,000-kw. generator which is being erected at Bradford Power station, from Newcastle to its destination. The handling of this stator is the greatest accomplishment of the kind so far achieved by the staff of the Valley Road Goods Station, where the load was entrained. For the purpose of transport a 12-wheeled truck 67 ft. in length and weighing 38 tons was used. The journey from the terminal railway station to the power-house was completed with a traction engine having rubber tyres.

U.S. ENGINEER'S JAPANESE MISSION.—A law having recently been passed in Japan requiring all hydro-electric power stations to provide at least 10 per cent. of their normal power output by means of steam generation, much new constructional work is rendered necessary. Mr. Francis Hodgkinson, chief engineer of the South Philadelphia Works of the Westinghouse Electric and Manufacturing Company, and an authority on steam turbines, has left for Japan to consult with and advise engineers in that country on various problems which arise in connection with the steam generation of electric power. It is of interest to note that Mr. Hodgkinson will take advantage of his visit to present messages of goodwill from the American Society of Mechanical Engineers to the Society of Naval Architecture and the Society of Mechanical Engineers of Japan.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—To-day at 4.30 p.m., at John-street, Adelphi, W.C.2. Indian Section. "The Industrial Progress of the Mysore State," by Sir Alfred Chatterton, C.I.E., B.Sc.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 6 p.m., at Storey's-gate, S.W.1. Extra General Meeting. "Some Tests on a Two-Stroke Cycle Oil Engine," by Professor E. A. Allcut, M.Sc.

THE DIESEL ENGINE USERS' ASSOCIATION.—To-night at the Engineers' Club, Coventry-street, W.1. "Pyrometry of Exhaust Temperatures of Internal Combustion Engines," by Mr. Charles E. Foster.

THE SOCIETY OF GLASS TECHNOLOGY.—Monday, May 25, and Tuesday, May 26. "Symposium on the Constitution of Glass." Monday, May 25, at 7.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. "The Nature and Constitution of Glass," by Professor W. E. S. Turner, D.Sc. "On Glasses as Supercooled Liquids," by Professor G. Tammann. "Some Remarks on the Constitution of Glass," by Dr. F. Eckert. "On the Constitution and Density of Glass," by Dr. A. Q. Tool and Mr. E. E. Hill. "On the Viscosity and Allotropy of Glass," by Professor H. Le Chatelier. Tuesday, May 26, at 2.30 p.m., at the University College, Gower-street, W.C.1. "The Structure of Quartz and Silica," by Sir W. H. Bragg, D.Sc., F.R.S. "The Viscosity of Glass," by Mr. V. H. Stott, M.Sc. "The Melting Relations of the Soda-Lime-Silica Glasses," by Dr. G. W. Morey and Dr. N. L. Bowen. "Polymorphic Transformations in Glass," by Dr. A. A. Lebedeff. "X-Ray Studies of Soda-Lime-Silica Glasses," by Dr. G. W. Morey and Dr. R. W. G. Wyckoff. At 7.15 p.m. Annual Dinner at the Hotel Cecil, Strand, W.C.2.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Tuesday, May 26, at 5.15 p.m., at Albemarle-street, W.1. "Passage of Electricity through Vacuum Tubes" (Lecture II), by Professor R. Whiddington.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, May 28, at 7.30 p.m., at Denison House 296, Vauxhall Bridge-road, S.W.1. Annual General Meeting. "Acoustics," by Mr. A. G. Huntley.

THE SOCIETY OF CHEMICAL INDUSTRY: CHEMICAL ENGINEERING GROUP.—Friday, May 29, at 8.15 p.m., at the Chemical Industry Club, 2, Whitehall-court, S.W.1. Annual General Meeting.

THE INSTITUTION OF CIVIL ENGINEERS.—At the Annual General Meeting of the Institution of Civil Engineers held on May 12 at Great George-street, Westminster, London, S.W.1, Sir William Henry Ellis, G.B.E., D.Eng. (Sheffield) was elected President of the Institution, while Sir Archibald Denny, Bart., London, Captain Matthew Henry Phineas Riall Sankey, C.B., C.B.E., R.E. (ret.), Mr. Ernest Frederick Crosbie Trench, C.B.E., M.A., B.A.I. (London), and Mr. Frederick Palmer, C.I.E. (London) were appointed Vice-Presidents.

THE UTILISATION OF UNDERGROUND STEAM.—During the past year, in Sonoma County, North-western California, and approximately 75 miles from San Francisco, natural steam has been passing up through 200 ft. of 8-in. iron piping and driving a 35-kw. turbo-generator. The steam, according to accepted theories, comes up from an extensive underground cavern, having a layer of spongy rock for a floor, beneath which is a mass of hot lava. Water from surface lakes drips down continually through numerous passages, percolates through the porous rock, and is transformed by the intense heat into steam, which rises into the cavernous chamber. Steam keeps escaping from this chamber to the outer air through crevices and vents in the earth's surface or roof of the cavern. Until the last few months, however, the practical future of this Sonoma County experiment has been problematical. Engineering tests had not been made, and the purity of the steam was, consequently, not known. Recently, however, the General Electric Company of America installed a trial turbo-generator, and made thorough tests of the steam at the wells. As a result of these experiments the natural steam was found to be 99 per cent. pure. It issues at a steady flow and a constant pressure of 60 lb. to 70 lb. per square inch, and has a temperature at the outlet nozzles of 335 deg. F. Engineers were considerably impressed with the possibilities, after making a careful examination. They thought it likely that a considerable volume of electrical energy could be produced, perhaps as much as 1,500 kw. per well, provided the necessary water-supply for condensation could be obtained in the vicinity. Already a plan is on foot to supply electricity produced with this earth steam to Healdsburg, a town of 2,000 population situated about 15 miles from Geyser's Canyon, the site of the wells. The calculated cost per kilowatt is only one-third that required for the installing of a small steam, electric, or hydro-electric plant. Considerable difficulty attends the sinking of wells. In one case the pressure became so great at a depth of 140 ft. that an explosion occurred, demolishing the casing and blocking the hole. Later, the use of iron steam pipe for the well casing enabled a depth of 203 ft. to be attained when a constant flow of superheated steam was secured. A 5-in. steam valve was installed on the pipe and completed the well. Fifty feet from the first well a second was drilled, 318 ft. deep. Well No. 1 supplied the power for drilling well No. 2. Although so close to the original well, the new tap has had absolutely no effect upon the steam pressure of the former. Other wells are in the process of being bored.

THE RECONSTRUCTION OF THE BOW POWER STATION.

MESSRS. HIGHFIELD AND ROGER SMITH, MM.I.E.E., CONSULTING ENGINEERS.

(*For Description, see Page* 635.)

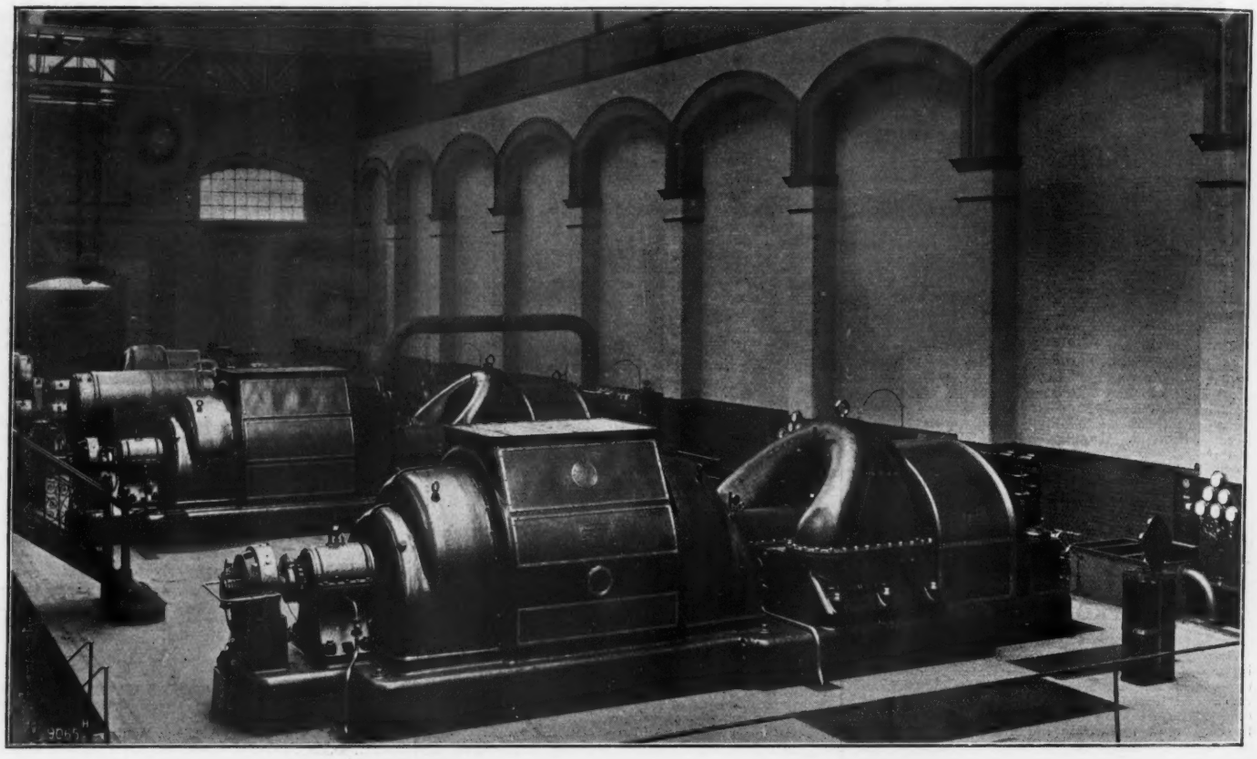

FIG. 7. INTERIOR OF ENGINE ROOM SHOWING 12,500-K.W. TURBO-GENERATORS.

FIG. 8. INTERIOR OF BOILER ROOM SHOWING FURNACE FRONTS WITH COAL METERS IN PLACE.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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ENGINEERING.

FRIDAY, MAY 22, 1925.

CREDIT INSURANCE.

THE proposals of the Federation of British Industries to the Government for the co-operation of the State in the insurance of credit have a particular interest for the engineering trades. The committee that has put forward these proposals was set up in response to the request of the Government for the views of industry on the subject, and its report appears to contemplate immediate action on practical lines. It seeks to promote and develop the export trade, in which British engineering manufacturers are gravely threatened, and it extends not only to the export of merchandise, in which all industries are concerned, but also to the longer credits required for facilitating capital developments abroad, the material for which is pre-eminently the product of engineering works. For the latter purpose, indeed, the Federation is of opinion that "further provision of a more financial nature may be necessary," and proposes to submit its views on the point to the Government at a later date.

Meanwhile the Federation's present suggestions deserve careful attention. They are made in the generally accepted belief that much more export business could be done if more extended credits could be given to the oversea buyer; and the committee was doubtless confirmed in that belief by the common knowledge that other manufacturing countries have obtained and enlarged foreign markets largely by offering credit facilities beyond those given by British makers. The simplest basis of credit is, in effect, for the seller as a term of the transaction to lend some part of his own capital and resources to the buyer. The credit that can be given on this basis, obviously limited as it always is by the seller's available resources, is now restricted more than ever. The capital resources of many firms have been reduced by their contributions to taxation and otherwise, and the value of any capital amount as a basis for giving credit has been reduced in something like the considerable proportion in which prices and expenses have increased. A second means of allowing credit is insurance against bad debts—in practice, against an agreed fraction of the losses—which may enable the seller to discount bills or obtain advances on the policies. This method has been tried to some extent, but in the view of the committee its scope is restricted by the fear of catastrophe; that is to say, of some unforeseen event that suddenly and simultaneously affects the solvency of many firms in one or more countries. The essential purpose of the Federation's proposals is on the one hand to minimise the effect of the catastrophe risk on the operations of credit underwriters, so as to enable them to extend their operations greatly, and, on the other hand, to make policies of credit insurance acceptable as security for immediate discount or advances.

It is suggested accordingly that traders should be left to negotiate credit insurances with underwriting companies as at present, except that in many cases it would be desirable for the insured proportion to be as high as 75 per cent. of the risk. To enable companies to underwrite such risks with no oppressive regard to the remote possibility of catastrophe, and their policies to become unquestionable security for discount and advances, the Government should undertake for a small premium to reinsure a large proportion of the excess of losses above some agreed abnormally high figure; for example, 90 per cent. of losses in excess of the company's aggregate premium income. Such reinsurance would be given only to companies of approved organisation, standing, and efficiency, and in respect of goods that the seller warranted under oath and penalty to be wholly or in an agreed percentage of United Kingdom origin. The report states that, as far as experience goes, the excess risk would be extremely small—presumably no larger than the equivalent of the premium; while through the increase of export trade the Government would secure an improved revenue, a reduced unemployment charge, the probability of a strengthened sterling exchange, and a gradual release from the responsibility and difficulty involved in operating the existing Export Credits scheme. To enable the policy to have the utmost effect in financing credit it should not be invalidated by any untrue representation or insufficient disclosure on the part of the assured, and claims should be payable immediately on the failure of the customer to meet his obligation on the due date. These unusual provisions, though the Federation believes the insurance companies would accept them in return for the Government reinsurance, would probably involve some increase of premium; but the Federation attaches the greatest importance to the credit risk being covered by a single and simple policy, especially with a view to rapid extension of business and to the interests of smaller manufacturers and exporters, and deprecates more cumbrous alternatives if they can possibly be avoided.

Measures such as these might have a far-reaching effect on export engineering trade. The provision, for example, that claims should be payable so soon as the customer makes default would be likely to call for a more considerable inspection service than is used at present. When a customer desires or is compelled to make default he is more likely to allege some defect in the goods than to admit candidly that he will not or cannot pay, and to avoid such a detraction from the prompt payment clause as would arise if the customer could lawfully take this attitude, the mechanism for satisfying both parties that the seller had actually fulfilled the contract of sale might have to be strengthened. Subject, however, to such executory details, there seems to be no reason why the proposed scheme should fail to increase the volume of export trade, provided manufacturers are in a position to make permanent use of it. The first condition of this is that the goods they offer shall be as suitable to the needs of their customers as those of manufacturers in other countries, and no more costly. Customers will doubtless welcome the offer of extended credit, though our own is by no means the only country that is likely to offer it; but they will not use it, except perhaps as a temporary expedient if similar offers have not arrived from other quarters, unless the goods are such as they want, and cost no more from British than from other manufacturers.

No one who is familiar with the resources of the

British engineering trades, both in designing and in manufacturing, can imagine that British manufacturers are less able than those of other countries to supply the special needs of individual markets; but it is idle to conceal the fact that they have taken less pains to ascertain them, and have shown less willingness to adapt their products to what individual markets require. It may be questioned whether this is due altogether either to an arrogant indolence, which requires customers to suit their needs to the manufacturers' standards, or to a native insensitiveness to differences in local requirements, though both of these dispositions are often suggested to explain the alleged fact that in many trades British designs do not readily follow the demands of individual markets. To ascertain these demands, and to modify standard designs or create new ones to meet them, may involve considerable expense, which prudent traders may not be justified in incurring without being assured that they can produce at an economical price and in competition with other countries. Yet if advantage is to be taken of the opportunity that the proposed extension of credit facilities is intended to create, these expenses must be incurred on the products of which standard British designs do not satisfy local requirements, and the cost of production, both of these and of standard products of which the design is acceptable, must be such as to allow competition with other countries on equal terms.

This is a condition that employers cannot fulfil by themselves. The largest element of cost is labour, and an essential condition of a competitive cost is that labour shall be used with at least the same economy as is shown by competitors. British engineering industry has been beaten on many occasions because it could not show that economy. Rules that may have been appropriate enough to a struggle between masters and men, but are hopelessly crippling to both when they are engaged in keen external competition, prevent many men from earning as much as they could, compel some of them to produce less than they could, and restrict most of them from doing work they could do in conjunction with, or as an alternative to, other work, with a saving of cost or increase of employment. If full advantage is to be taken of the present opportunity, employers will need to be assured that the work will be freed from these restrictions. Even if the whole of them were removed, British workmen would still be earning more than those of any other country, except the United States, where such restrictions are practically unknown. The removal of the restrictions would add nothing to the rate of profit of employers, who have to pass on to the consumer any savings that result; without their removal, the handicap under which the joint enterprise of works and men are competing seems likely to make successful competition impossible, and to frustrate the opportunity that extended credit facilities might offer. The situation is one that industrial leaders of trade unions must realise. For the sake of their members, their industries and the country, it is to be hoped that they will give effect to their convictions.

If manufacturers are enabled to make the showing in competition that would be possible with a united front, the administration of the increased credit insurance, and the further provisions that the Federation is likely to suggest, may also be a step towards the creation of an Imperial home market. No richer fields for development exist than are to be found within the Empire, and if the manufacturers of this country are able to compete with others in design and cost, no more fruitful use could be made of the suggested increase in trading facilities than to devote them primarily to extending inter-Imperial trade.

TRANSPORT ORGANISATION.

SPEAKING at the Congress dinner of the Institute of Transport last week, the Home Secretary mentioned that he felt reluctant to impose restrictions with a view to eliminating the practice of crawling amongst London taxi-drivers, as they would be likely to involve great hardship on the small owner. We fear that a committee which it is suggested that the Institute should set up to consider transport organisation will meet with the same difficulty on a more extended scale. The fact is that we have travelled so far from the simple life that those whom we have elected to legislate on our behalf have to constantly impose hardships on the individual for the common good. The proposal to appoint a committee followed on a paper read on the co-ordination of rail and road transport by Mr. D. R. Lamb before the Congress, and more than one of the representatives of the larger road transport organisations who joined in the discussion gave the impression that they regarded the small man as having no legitimate status. Such a view may be economically, if not ethically, sound, but if this is so it can only be regarded as regrettable. We confess to rather an admiration for the man who, breaking no law, is prepared to stake his slender resources in an endeavour to earn an honest living. He is called hard names by his larger competitors, but in truth his only crime is the retention of a spirit of adventure in these hundrum times. It would not be amiss in many cases if those who dubbed him pirate would look back on the beginnings of their own enterprises, and seek to define the difference between their own actions in the past, and that of those they condemn in the present. If individual enterprise in this or any other direction is to become impossible, we greatly fear that the organisation of civilisation is being overdone, but fortunately we are still far from such a condition.

The terms of reference suggested by Mr. H. Mattinson for the committee which he moved should be elected, are to ascertain what steps can be usefully taken to organise the various forms of transport used on the highways of the country, and to co-ordinate their interests with those of the railways. We believe that it will be very generally admitted that some action along these lines is desirable, as the present position is decidedly unsatisfactory. In his paper Mr. Lamb suggested that the subject would be a fitting one for the consideration of the Institute of Transport in conjunction with the Standing Joint Committee of Mechanical Road Transport Associations. He also mentioned that there was no body other than the Institute capable of dealing with a controversy of this nature efficaciously, as no other technical institution comprises within the same membership so many leading representatives of the different warring elements. This statement, while lending support to Mr. Lamb's contention, also appears to contain an element of danger. The question of co-ordination may be regarded from two points of view, that of the public on the one hand and the shareholders in the transport companies on the other, and the former will not be slow to perceive that the two are by no means necessarily compatible. The public rightly regard the existence of competition as a safeguard of their interests, and a considerable amount of educational work is requisite to convince them that combinations and working agreements are in the interests of anyone but the shareholders of the companies concerned. In some cases the suspicion of the public is no doubt justifiable, but in general some measure of combination in business can be said to be in their interest under modern economic conditions. In cases where such combinations prove advisable we are of opinion that a deliberate effort should be made to bring home the fact that the public are really benefiting, and we might quote the recent railway combinations as an example where such propaganda has been unfortunately neglected. The public have been quick to discover the disadvantages resulting from this combination, but are apt to take the ensuing advantages as a matter of course.

Any bias which the committee may possess would be largely offset if the constitution could include representatives who are purely concerned with the public interest. So far as we know, the only body which directly represents this interest on transport questions is the Ministry of Transport, and we hope that the appointment of an official of the Ministry will be considered if it is at all practicable. The committee would have no government status, and such an appointment could, therefore, be entirely unofficial. Perhaps, however, the best guarantee that the interests of the public will receive due consideration lies in the names of the various distinguished men who mould the policy of the Institute. Probably the greatest difficulty in constituting the committee will be to give representation to the small passenger or goods carrier who owns only a few vehicles, but who nevertheless in the aggregate represents a heavy interest in the transport question. As we have already remarked, the policy of some of the larger organisations is to attempt the entire elimination of this element, but we feel assured that such an attitude on the part of the committee would be a serious mistake, and would result in the forfeiture of the confidence of the public. The latter will ultimately be called upon to pay the piper, and it is perhaps sufficient to remark that the final success or failure of any measures formulated depends on their approval.

Turning now to the terms of the proposed investigation, the primary object is to attempt to co-ordinate the interests of the railway companies on the one hand, with those of the road transport companies on the other. Each believe that they have a grievance; for, while the railway authorities feel that they are entitled to wider road-carrying powers to enable them to meet competition effectively, the road carriers suspect the railways of an intention to run road traffic at an unremunerative rate until such times as they have stifled competition. Unfortunately, however, it would appear that the crux of the antagonism between the two interests lies in the question of the incidence of rating. A most contentious issue is thus introduced, and the arguments on both sides involve such wide issues that any settlement acceptable to all parties appears impossible. A discussion of the rating question involves the owner of every type of vehicle using the roads, and would raise the question of the damage done by each type, as well as the extent to which each constitutes a public necessity. We do not, of course, know whether the committee would regard this issue as relevant, and the point has presumably not yet been raised, but the attitude taken by some of the speakers who joined in the discussion on Mr. Lamb's paper would justify a decision to accept the present system of rating as a basis of all new proposals.

Assuming this decision were reached, ample matter would still be left for discussion, and the ground would be left clear for compromises of a practical nature. Mr. Lamb referred in his paper to a number of points on which co-operation might be of advantage. He suggested that more generous rates of payment on the part of the railways for services rendered by the road companies would attract the goodwill of the latter, and would result in an increase of traffic to their mutual advantage. Unremunerative rail services might be performed by road transport, and much unprofitable handling of goods by the railway authorities could be avoided by the use of road vehicles for consignments to suburban areas. As regards omnibus and motor-coach services, the actual number of passengers might be greatly increased by the inauguration of through facilities. These and similar proposals afford ample ground for co-operation of a nature that might equally result in benefit to the railway companies, the road organisations and to the general public.

EXPLOSIVES IN MINES.

DURING the South African War the purchaser of an evening paper is reported to have returned this to the vendor, with the request to be given in exchange the flamboyant poster, which had led to the purchase, and which, he asserted, seemed to contain the most news. This story is recalled by the second report of the Explosives in Mines Research Committee, which has just been issued by H.M. Stationery Office, price 3*d*. Accompanying the report is an advertisement concerning it, which seems to contain nearly as much information as the main document. The latter gives very little, and in one sense at any rate, some of this little is wrong. We refer to the claim that "fundamental" researches are in progress, whereas what is really meant is that comprehensive investigations have been undertaken. The distinction between the

two is itself fundamental. The famous Michelson-Morley experiment was undoubtedly fundamental, so also was the work of Becquerel on radioactivity. On the other hand the investigations of Madam Curie, highly fruitful as they proved to be, were merely a comprehensive extension of Becquerel's fundamental work. Similarly, the observation of Scheele that silver chloride was blackened by exposure to light was fundamental, but had a successor, knowing this, merely tried the effects of replacing the chlorine by other halogens, this research would merely have been comprehensive, although of the very same type as that for which the official research boards claim the title of fundamental.

In actual fact fundamental researches such, for example, as the isolation of the electron, or the determination of the structure of the atom, are seldom or never made by Research boards and their coadjutors. There is, of course, nothing to complain of in this. "They also serve who only stand and wait," and much more than this must be credited to the patient and industrious workers who supply us with most of our scientific and technical data.

Returning to the explosives report it would seem that the main reason for its paucity of interest lies in the circumstance that the various investigations now in hand are still far from completion, whilst some of the others would appear to be concerned with trivialities. "Empirical" experiments are being made in continuation of those, in which it was proved that fire-damp mixtures could not be fired by "permitted" explosives unless used in excessive charges. The firedamp has been replaced by methane, and the conditions have been varied by changing the position of the gun and the loading density, and also by reducing the diameter of the gallery. Experiments have also been made in the ignition of mixtures of coal dust and air. This, it was found, could not be effected with any of the permitted explosives, but with other types ignition was readily obtained. It may be noted that the piezo-electric properties of tourmaline are being used to measure the pressures attained in gaseous explosions. This application of piezo-electric properties was, we believe, first suggested by Sir J. J. Thomson in connection with experiments on submarine mines.

An interesting but perhaps valueless point was established in some of the so-called "fundamental" researches, it being found that coal dust could be electrified by blowing it through a copper tube. It is suggested that there is "an evident danger from circulating clouds of mine dust if sufficiently high electrical potential differences are reached to cause the passage of breakdown sparks." We may observe, however, that coal dust in the workings is never blown through copper tubes, and in the absence of these it is at least possible that the electrical effects would be little or nothing. The possibility of dangerous electrical potentials being generated by dust whirls in the workings seems very doubtful, and the question can certainly not be settled by experiments on copper tubes. The value of the observations thus obtained is in no way enhanced by dubbing them fundamental.

In this connection reference may perhaps be made to a letter of Sir Joseph Larmor, which appeared in the *Times* of last Wednesday. In this the writer noted that over 4,000,000*l.* was provided in the Government estimates for scientific research. This, he says, is an astonishing sum when contrasted with all the income of all the universities in the land. There is, perhaps, not a little reason to fear that no inconsiderable fraction is being expended on futilities. For example, it is rumoured, that the one research department is instituting a series of accurate measurements of the crank effort expended by labourers turning a crane handle. It is difficult to see in what way the information thus gained can be valuable either technically or medically.

ROAD RISKS.—An attractive and useful booklet entitled "Road Risks Illustrated" has been issued by the Royal Insurance Co., Limited, of 1, North John-street, Liverpool. A large number of illustrations showing motor-car and motor-cycle accidents of an unusual type with explanations of the legal point of view in each case forms the major portion of the publication.

THE PRINTING AND ALLIED TRADES EXHIBITION.

THE Printing and Allied Trades Exhibition in the Royal Agricultural Hall, though its contents are about 80 per cent. British in origin, is of an international character, and it affords an opportunity of studying the trend of development in the United States of America and on the Continent of Europe. In addition to a very exceptional display of printing machinery there are exhibits of work of great merit produced by its use, and those who appreciate the value of artistic printing may spend time in a very instructive way, studying the rare collection of printed books loaned by Mr. George W. Jones or even examining what has been done by the students of printing in the technical colleges. The Exhibition remains open until May 30.

Of the actual exhibits of printing machinery perhaps the most exceptional example is that of the Typary and Typon Company Limited, of 1 to 4, Red Lion-passage, London. In all, the development of the methods employed in offset lithography, there has always been present the great handicap that it was necessary to go through the entire routine of letterpress work, composition, correction, making up the formes and putting them on the machine, in order to obtain a single good copy for the photo-reproduction work. With the Typary machine the equivalent of a first proof, properly set and spaced, is produced by the mere operation of typewriter keys and the type is distributed, line by line, immediately after use. The machine is operated by an electric motor drive, but it does not print as each key is depressed, as is the case with an ordinary typewriter. Only when the line is complete, automatically spaced and justified is the printing of the complete line performed. The number of type keys is 84, which gives with the shift devices a choice of 225 separate characters. These include everything in a complete fount of type, even to "em," "en," quads, spaces, &c. Indentations may be made for the introduction of illustrations and the lines may be set out for tabular matter. A dial with a moving indicator measures off the typographic points as the operator types the line, and is placed immediately above the keyboard. When the type-bars have been thrown out across the table through the twin guides to their proper locations a projecting device attached to a traversing carriage correctly aligns the type. Following the aligning mechanism an inking apparatus, similar to that of an ordinary machine printing press, moves across the type. A platen then moves forward and down over the type and the impression of the type is made, after which the platen returns to its normal position, and the proof sheet bearing the imprint is moved forward one space on the platen. Once the operator has keyed out a line of type the time taken to assemble it, align, justify and ink the type, make the impression and for the platen to return is approximately 12 seconds, but he can proceed to type the next line as soon as the recording dial showing the points returns to zero, which takes place as soon as the automatic process of assembly starts. Should a mistake be made the distributing lever can be brought into action by a pedal, and the type returned to the magazine without going through the printing process. It is claimed for this machine that it is capable of recording something of the order of 10,000 letters in one hour.

The same firm have introduced a new photographic paper, which they have named Typon. This can be used to obtain a negative by simple face-to-face contact with the printed page obtained from the Typary machine or, indeed, from any printed matter which has to be reproduced to the exact size of the original. It is a special kind of bromide paper which is exposed in contact with the copy in a printing box which contains a number of half-watt lamps. As the paper used is of the stripping kind, the negative after drying may have the paper backing removed from the film by the simple expedient of raising the corner and pulling it off. A thin, flexible and tough negative is thus obtained which is ready to print down on to the zinc, and the development and fixing are carried out in the usual way. By the use of this paper it is possible to reproduce the negative, develop it, and have it ready for printing down on to the sensitised zinc plate in a very few minutes.

An interesting exhibit of standardised printing machinery is afforded by Intertype, Limited, of 15, Britannia-street, London, W.C. 1. This consists of a machine to which magazine units may be added whenever required, as well as side units for head letter or display work, until the machine may be converted eventually into an ideal jobbing machine. As all the magazines, matrices, moulds, &c., are interchangeable, very flexible working is obtained. Any machine which carries a required font of matrices need not be interrupted to handle some rush work or set of proofs. The magazine containing the required matrices may be removed and placed on any other Intertype machine.

H.T.B., Limited, of Blackhorse-lane, London, E. 17, show their full- and semi-automatic pile feeders attached to a single-colour rotary offset press made by Linotype and Machinery, Limited, of Broadheath, and to other machines made by Messrs. G. Mann and Co., Limited, of Leeds, and Messrs. Marinoni of Paris. To the general printer the semi-automatic feeder is perhaps of greatest interest, for by its use accurate register at any speed up to the value of 6,000 impressions an hour can be obtained, which covers all the common requirements. Though the machine takes up little space behind the printing press, it enables an increase in output compared with the best hand feeding of 30 per cent. to 100 per cent., depending on the nature of the work. In this machine all the trips and untrips are worked automatically. All the adjustment that is necessary is in the side-lay for the sizes of the sheets.

Included among the electric equipments for paper working and printing machinery exhibited by the British Thomson-Houston Company, Limited, of Rugby, there is a variable-speed motor of the polyphase alternating-current type. This has push-button control giving "start," "stop," "creep," "on" and "off" in one case, and "raise speed" and "lower speed" in another. The motor exhibited is capable of giving 25 h.p., and runs at 1,400 r.p.m. to 450 r.p.m. on a three-phase supply at 400 volts to 440 volts and 50 cycles. It is fitted with a pilot motor, operated by push buttons to effect the speed variation, which is obtained by movement of the brush system. In some cases it is possible to eliminate the pilot motor and obtain the speed variations through the medium of a hand wheel. A great variety of drum-type starters, totally-enclosed panels and other B.T.H. equipment for printing machine drives is also displayed.

Just as the makers of electrical equipment for the driving of machine tools have perfected control panels to suit all the required conditions of running, they have devoted themselves similarly to the necessities in connection with printing machinery, and Electromotors, Limited, of Openshaw, illustrate this in an effective way. On their stand there is shown a complete electrical equipment for the operation of a rotary press on their "Gem" system.

Messrs. J. H. Holmes and Co., of Portland-road, Newcastle-on-Tyne, display a model of the Holmes-Clatworthy two-motor equipment for the driving of rotary web printing presses. By its use the machinery may be started smoothly from rest and accelerated evenly without causing the breakage of the paper. In conjunction with this there is exhibited a full-sized controller for a rotary press operated by push buttons.

A selection of their latest models of cardboard box-making and cross-stitching machines is provided by Messrs. Vickers Limited, of Vickers' House, Broadway, Westminster. Included amongst them is a new type of corner staying and ending-on machine driven by a self-contained electric motor. In this design the return and friction springs of the earlier models have been eliminated and a positively-operated paper gripper has been introduced. By the reduction of working stresses through careful design, higher working speeds have been obtained without loss of reliability or impairment of the quality of the products.

The well-known melting furnaces made by the Monometer Manufacturing Company (1918),

Limited, of 115, Strand, London, are effectively displayed. These have mechanical mixers, temperature controllers, detachable elbows and flow pipes and reversible water-cooled ingot moulds.

A high-speed envelope folding and gumming machine of a type newly introduced to the market is shown by Messrs. Dawson, Payne and Lockett, Limited, of Dean-street, Fetter-lane, London, the agents of the makers, Messrs. David Carlaw and Son, Limited, Glasgow. This, though built on the ordinary "Leader" system, has had new features introduced in order that a speed of production of 185 envelopes per minute can be maintained. One of the distinctive features is the replacement of the usual cam drive for the plunger by a semi-rotary movement. The delivery system is entirely rotary and no grippers are used for it.

On the stand of Messrs. Lorilleux and Bolton, Limited, of 31, Cursitor-street, Chancery-lane, London, there is shown a very simple and effective means of testing the permanency of coloured pigments. In the centre of a casing is mounted a lamp, the light from which has a high actinic value, and which has the characteristic of giving uniform illumination. The colours to be tested are printed or painted on papers which are introduced into small slides at gaps in the casing. By comparison with the fading effects caused by sunlight it has been found that 20 hours' exposure, under the prescribed conditions, to the rays from the standard lamp is equal to one month of bright sunlight. By the use of this simple and effective means it is possible to classify pigments, such as might be proposed for printing posters, according to the way in which they will withstand sunlight, with a great reduction in the expenditure of time.

THE ROYAL SOCIETY SOIRÉE.

(*Concluded from page* 615.)

THE exhibits of the National Physical Laboratory included two examples of the new all-metal types of Backhurst-Kaye mercury-vapour pump; very high rates of evacuation, demonstrated by providing adjustable leaks, are obtained by effecting the diffusion of the vapour at the throat of a Venturi stricture. The Laboratory also exhibited examples of the photo-electric cells of Mr. T. H. Harrison which are employed for the exact colour-matching which has been found essential for the accurate standardisation of incandescent lamps. The method was developed in the Research Laboratories of the General Electric Company at Wembley. The property utilised is that photo-electric cells containing a film of sodium, become more sensitive, and rubidium cells less so, as the temperature of the lamp is raised. A rubidium and a sodium cell are connected in series, and the photo-electric currents are balanced against each other when the two cells are illuminated by the same lamp; in this way lamps are matched within 1 deg. C. absolute of the equivalent temperature and within 0·1 per cent. of the volts.

Dr. W. Rosenhain demonstrated some peculiarities in the formation of Neumann lines in iron. When small prisms of nearly pure iron, having one vertical face, are compressed, slow strain produces slip bands, but impact sets up Neumann lines. In a recently deformed specimen impact does not call forth Neumann lines, but they appear when the specimen has recovered by ageing, and is then submitted to impact. Dr. Ezer Griffiths exhibited several new simple forms of carbon dioxide measuring instruments, especially designed in connection with the cold storage of fruit in ships' holds. The one form consists of a glass tube, nearly 2 in. in diameter, bent to a circle so that the two closed ends almost meet; the tube contains some mercury which, when the tube is turned by hand about an axis vertical to its plane, transfers the air drawn in near the one end over to the other end and sends it into an axial tube charged with soda lime; two two-way taps are required for the manipulation of the pump. The principle of the other pump is similar; it is a piston pump with a vertical barrel, parallel to which the soda lime tube is fixed for the absorption of the CO_2. The third more delicate device, a Hayes apparatus, makes use of caustic soda solution; to prevent any splashing over of liquid in the tubes when the ship is tossing, a float has been inserted in the liquid column. The last exhibit coming from the National Physical Laboratory was the portable apparatus of Mr. J. Hollingworth for the measurement of the intensity of long-wave radio signals; a generally similar non-portable form has been used at four stations in the British Isles.

The Research Department, Woolwich, also had some interesting novelties. The ingenious apparatus for the study of colloid structures—due to Mr. H. J. Poole, who described it in the Faraday Society last January—is essentially a constant temperature extensometer; it is used for measuring the Young modulus and the shear modulus of jellies and determining the creep modulus; cordite has been shown to have the structure of a two-phase liquid, both the phases being continuous. The colloid nature of cordite was also brought out by Dr. West's X-ray photographs. In the Debye-Scherrer method a crystalline solid like graphite shows distinct dark rings, but colloids only diffuse darkness. Dr. West further exhibited some comparative microphotographs of steel specimens, broken on a tensile machine, and X-ray spectrograms of the same. In the ordinary photographs (at magnification 50) the crystal boundaries remained almost unchanged as the stress increased; the spectrograms consisted of a ring system in which "asterism"* afterwards developed; finally, the hexagonal pattern stood out very clearly. In the apparatus of Mr. R. Ferguson (also of Woolwich) for determining the flash velocity and pressure factors of igniting detonators, use is made of the high electric conductivity of the hot gases liberated by the ignition of the detonator. The detonator is placed on the top of a vertical steel tube resting on an anvil. The hot flash passes down the tube into which, at two points, 9 in. apart, platinum wires are inserted to form contact gaps, each in a circuit comprising a battery, condenser and one string of an Einthoven galvanometer; the hot gases close the circuit, and a record of the moments and the time taken by the flash to pass the specified distance (0·003 or 0·004 second) is thus obtained. The pressure is determined by means of the piezo-electric charge produced in a tourmaline crystal, placed between the tube and anvil, which is connected to the grid of a balanced valve; the anode current is recorded by a ballistic galvanometer. The use of a new arrangement for spark photography of flying bullets was also demonstrated. Near the muzzle of the barrel a nipple is attached to the barrel in which a piston moves up as soon as the bullet leaves the rifle. A disc at the upper end of the piston approaches a condenser. A spark is produced without the aid of contact wires, and the difficulties of insulation and of working near the sparking potentials of the spark gas are avoided. Photographs of the air disturbances by the bullets were also exhibited.

The Ordnance Committee of the Royal Arsenal, Woolwich, showed the trajectograph designed by Messrs. A. F. Ravenshear, T. Chaundy and F. Lewis during the war for determining the flight of a projectile in a resisting medium. The trajectory is drawn by the machine on a metal board by a knife edge or hatchet guided by similar hatchets, the movements of which are electrically recorded; from this the instantaneous velocity is deduced.

The telephotographs exhibited by the International Western Electric Company were excellent. The photographs, untouched negatives or prints, of Faraday, Alexander Graham Bell, the Washington Capitol, &c., had been transmitted last month by telephone wires, from, or to, New York, Washington, San Francisco (3,300 miles), &c. The negative, 5 in. by 7 in., is wrapped round a drum of transparent material, and the beam of a lamp is first focused on the left-hand upper corner of the drum, which rotates about its horizontal axis while advancing by 0·01 in. in each revolution; the beam travels in a spiral of 700 close parallel lines all over the negative in 7½ minutes. The light passing through the negative and the drum falls upon a photo-electric cell containing a potassium alloy, which is joined to the telephone line. At the far end the currents flow through a light valve consisting of a fine wire, which uncovers and covers a small rectangular orifice in front of a similar drum wrapped with sensitised paper. Synchronism of the two drums is maintained by means of currents of 400 cycles, interrupted by correcting signals, both controlled by tuning forks. The system has been taken up commercially. The audiometer of the same company tests the sensitiveness of the ear to sounds of different frequencies (64 to 8,192) produced by the tuned oscillator of a box instrument; the patient puts a microphone to his ear, and the sounds are weakened by throwing in resistance. The artificial larynx of the firm restores vocal power to persons who have had the larynx removed, and the electric stethoscope, a large box to which stethoscope tubes are attached, enables many students to listen simultaneously to the heart beat or other body sounds, which may be separated by the aid of electric filters.

The examples of electro-plated ware, exhibited by the Metropolitan-Vickers Electrical Company, comprised fittings coated with non-tarnishable chromium, which looks well, though rather dark; it is deposited from chromic acid baths with chromium anodes, which are generally credited with a troublesome tendency to turn passive. Iron ware with rust-proofing cadmium coatings was likewise shown. The noise-frequency analyser, which the firm has found useful, is one of the modern instruments for checking the running of machinery. The noise of a machine or workshop is picked up by a magnetophone, amplified and received in a telephone in which the oscillations of a calibrated audio-frequency valve are superimposed until beats are heard; thus predominant noise frequencies are determined. The low-impedance thermionic valves exhibited by the company, the invention of Mr. E. Yeoman Robinson, look very different from ordinary valves. A large space is taken up by the sheet anode, which is built up of two thin sheets of molybdenum, so bent and welded together that two longitudinal tunnels are formed, in which the filaments are stretched. The anode is supported by lateral glass rods, and the two filaments, electrically in series, are held in tension above and below by strips of molybdenum. The supports of the grid-wire helix operate as shields. This shield action, the short, confined paths of the electrons in the tunnels, and the cooling of the electrodes by the large support surfaces are said to reduce the impedance of the valves and so allow of their being operated in a low vacuum.

The very simple double-cube lumen comparator of Professor MacGregor-Morris and Mr. A. H. Mumford does not depend upon any adjustments of the lamp currents. A box, whitened inside, is divided by a vertical partition into two cubes containing, the one the lamp tested, the other the standard. In front is a window, with a back and front glass, crossing the partition; the illumination falling upon the window is adjusted by means of a lever actuating an eccentric diaphragm mounted between the two glasses until the two semi-circles appear of equal intensity.

Among the exhibits of Messrs. Adam Hilger were photographs of the interferometer, supplied to the Japanese Government for establishing the metre in wave-lengths of light (described on page 491 of our issue of October 3, 1924); remarkable Lummer-Gehrcke plane parallel plates of faultless quartz, 180 mm. in length, bearing at one end a small quartz prism, merely in optical contact (not cemented on); and the latest form of the Müller universal X-ray spectrograph, for use also by the methods of Laue and Schiebold. In the latter the crystal mount is replaced by a two-circle goniometer, made up of an upper and a lower arc at right angles, sliding in one another in such a way that the crystal always remains in the centre while being continuously rotated by means of a worm gear and bevel wheel. Exact centring of the crystal, with one edge parallel to the axis of rotation, is secured in the first instance optically, by means of a small telescope, or by a preliminary X-ray examination; the method is convenient for prolonged work.

The settlement dust counter of Dr. J. S. Owens,

* We should refer our readers to our article on the "Stress Strain Studies of Czochralski as to Asterism," ENGINEERING, December 21, 1923, page 762.

exhibited by the Advisory Committee on Atmospheric Pollution, is a new instrument designed for examining the coarse dust raised by such processes as grain unloading. Into the six circular cavities of a brass disc are fitted miscroscope cover glasses, previously wetted with a highly diluted solution of Canada balsamin xylol; the lid, which has one hole, is at once put on the disc. On the lid is placed a brass cylinder, 100 mm. high, which has been held in the air to be examined with both ends open, and the cap of the cylinder is then quickly put on. The dust begins to settle; by means of detents the glasses are successively brought under the hole at intervals of, say, 15 seconds, and the rates of settlement of fine and coarse particles are thus ascertained. The numbers of particles are afterwards counted under the microscope. As the dry fine dust might be blown off during manipulation, the cover glasses are kept wet by xylol evaporating from blotting paper.

In the magazine hair-break tester of Dr. W. Lawrence Balls, exhibited by the Fine Cotton Spinners' and Doublers' Association, fifty cotton hairs are mounted radially across slots at the edge of a metal disc and fixed by means of hot wax, the inner end of a hair to the disc, the outer to a brass eyelet resting at the extreme edge of the disc. Into the eyelet drops the hook of a pendulum, the carriage of which slides to and fro. From a needle point of the pendulum a continuous stream of sparks (from an induction coil) passes to a paper disc held against a ratchet wheel. As the carriage moves away from the magazine the pendulum is held back until the thread breaks, and the length of the curve—an arc of separate dots—is a measure of the strength of the hair. The magazine is rotated through one slot for each traverse of the carriage, and the ratchet wheel is turned through one tooth. The variability of the cotton hair strength necessitates tests of many specimens.

THE INSTITUTE OF TRANSPORT CONGRESS.

(*Continued from page* 611.)

THE afternoon session of Wednesday, May 13, was taken up by visits to the South Lambeth Depot of the Great Western Railway, the works of the Vacuum Oil Company, Limited, at Wandsworth, and to the Kennington to Morden extension works of the London Underground Railways. These visits were followed in the evening by the sixth dinner of the Institute at the Hotel Cecil, at which the principal speakers were the Minister of Transport, the Home Secretary, the Rt. Hon. Lord Carson of Duncairn, the Solicitor-General, and Colonel Sir Joseph Nall, the President-elect of the Institution. The chair was taken by the President, Sir Lynden Macassey.

THE CO-ORDINATION OF RAIL AND ROAD TRANSPORT.

The morning session on Thursday, May 14, was occupied with the reading of a paper on "The Co-ordination of Rail and Road Transport," by Mr. D. R. Lamb. The chair was occupied by Sir Henry P. Maybury, K.C.M.G., C.B., who is a Past President of the Institution.

The following is a summary of Mr. D. R. Lamb's paper:—The relative position of rail and road transport is a subject of acute controversy, and, in this paper, the present position is set forth in commercial road transport as affecting the railways, road hauliers and traders. The road activities of the railway companies are mainly confined to the collection and delivery of goods before and after rail conveyance. The companies are under no obligation to perform the service of cartage, though they must provide reasonable facilities for receiving, forwarding and delivery traffic. The trader who carts his own goods is entitled to a rebate should the rate charged by the company include collection and delivery, but the rebate is, in general, based only on the saving accruing to the railway by reason of its not having carried out the work. The question is, however, materially affected by the Railways Act of 1921.

The railway companies have, with certain exceptions, failed to secure the road-carrying powers they consider requisite to meet growing competition and to perform the service of transport more economically. The carrier by road can choose the most remunerative traffic at will, but the chief concern of the railway companies is the existing basis of taxation for road maintenance. Two-thirds of the cost of road maintenance is made good by the ratepayers, of which the railways claim to be the largest in the kingdom.

The objections of the road hauliers to any extension of the powers of the railway companies are summarised in the Report of the Departmental Committee on Road Conveyance of Goods by Railway Companies, in 1921. As far as taxation is concerned, it is argued by the road haulier that he is carrying out a commercial service which is of value to the community, and that he is therefore entitled to preferential treatment as compared with the private-car owner. The trader holds the view that an alternative form of transport to the railways should be encouraged as a safeguard against the dangers of monopoly and strikes. From the proceedings during the committee stage of the Railways Bill of 1922, it would appear to be the view of the Ministry of Transport that the railway companies should only be allowed to charge for conveyance by road the same rates as those obtained by rail, including terminal charges. This view was unacceptable to the promoters, who withdrew the Bill, and it is certain that a difficult task would confront the companies in any further effort to secure road powers. The foregoing circumstances point to the necessity for an endeavour to secure co-operation between the various interests.

As regards essential characteristics, railways are the principal, and most reliable, means of transport in the country. The drawbacks suffered by railways in comparison with road transport may be summarised under the headings of track, transhipment, time and risk. As a basis of co-operation, it is suggested that the road is more suitable for short-hauls and the railway for moderate or long-distance conveyance. The big goods depots might be used for road as well as rail transport, the aim being to dovetail road and rail facilities at the depots to general advantage. In drawing up a set of rules, the railways are so organised that there would be no difficulty in arriving at and enforcing an agreement, but road transport is lacking in any kind of organisation, very few even of the big provincial cities possessing any co-ordinating medium. Pending a national agreement, it might be possible for the two parties to adopt a working arrangement by means of which additional traffic could be secured to the railways from sources beyond their normal collection and delivery areas, and by which unremunerative rail services might be performed by road transport.

In connection with the first proposal, new territory could be opened out by road transport as an alternative to new branch or light railways. Through rates by road and railway might then be arranged, the road-haulage firms nominated by the railway for any particular zone agreeing to maintain a regular service in conjunction with the railway company's schedule. For this and similar proposals to be successful, the terms of payment to the hauliers must be on a more generous scale than the system of rebates at present ruling. As regards unremunerative rail services, one of the most unsatisfactory in this direction is the handling of goods passing to and from the smaller stations on branch lines, or even intermediate stations on main lines. This class of traffic might be dealt with more economically by road motor services in place of "pick-up" goods trains. Considerable progress has been made in this direction in the United States, particularly in connection with terminal work. More extensive use of road transport might also be made by the railway companies in the collection and delivery of suburban traffic. Under present arrangements, excessive stock has to be used, with needless haulage of lightly-loaded wagons, and much unremunerative engine time is spent in shunting and standing. The work has often to be carried out on lines which are already congested with suburban passenger traffic and is subject to other disadvantages of a minor nature. A considerable degree of co-operation of this nature already exists in the United States, and offers an answer to the argument that such work could only be performed economically if the road vehicles were owned and operated by the railway companies. It should be remembered, however, that American railways do not, in general, possess cartage establishments of the type usual in this country. Under suitable circumstances, containers are of value in reducing time and labour in connection with road and rail transport. They are chiefly of value where a fairly even flow of traffic exists, both forwards and backwards. They might possibly offer advantages for regular use between the larger cities, where a considerable flow of regular traffic is assured.

Turning now to passenger transport, this may be summarised firstly as motor-omnibus services, and secondly as motor-coach services. As regards the former, their encouragement in districts which are not already served by rail is an obvious advantage to the railway companies. Such encouragement might take the form of free permission to make use of the station yard and other private accommodation, and the issue of through road and rail season tickets. As regards motor-coach services, somewhat similar action might be taken, and extensive rail-*cum*-road tours instituted under railway auspices. This has already been done to a considerable extent in France.

The discussion, which was opened by Mr. E. S. Shrapnell-Smith, showed that a wide divergence of opinion existed on a number of the issues raised in the paper. The opinion appeared to be general that any effective measure of co-operation would be extremely different to negotiate, and it would seem that the crux of the difficulty lies in the feeling of both sides in connection with the incidence of rating. The issue, as regards the railway companies, was ably summarised by Mr. Shrapnell-Smith, who referred, amongst other points, to the heavy contribution to road maintenance paid by the companies. He pointed out that the total cost of the highways to both ratepayers and taxpayers amounts to approximately ½*d.* per head per day, and that as the railways are the largest ratepayers in the kingdom, they were the largest individual subscribers to the heavy total. Apart from their contributions to road maintenance, the railways have a very heavy charge to meet on their own track, the maintenance amounting to about 12 per cent. of the cost of the permanent way. The speaker referred to the fact that, whereas the figures covering the contributions made by the railway companies were easily obtainable, those referring to the contribution of the road organisations were not published. In view of the diverse sources from which the latter are obtained, it would appear to be a very difficult matter to analyse them with a view to arriving at their exact incidence, but this would be necessary before any discussion regarding readjustments could be effective.

Another point which received considerable attention in the discussion was the lack of any organisation competent to represent the road interests at a conference. Mr. Lamb referred to this point in his paper in suggesting that an endeavour might be made to secure some national organisation in road transport, but one of the most striking characteristics of the latter is the extent to which those who participate are divided amongst themselves. In this connection, Colonel A. Hacking expressed the opinion that omnibus companies must be protected from irresponsible competition, and although this may be justifiable in certain cases, it would be impracticable to carry the same policy into the general carriage of passengers and goods on the roads since a large proportion of the total service is conducted by the small owner. The very large number of traders who conduct their own transport presents another difficulty, as without being interested in collaborating with the railways, they have a direct concern with the incidence of taxation. Mr. Shrapnell-Smith suggested that before the railway companies made concessions, some guarantee should be afforded that the additional traffic offered as an off-set would be forthcoming, but the lack of any road organisation above referred to would appear to make this impracticable. Mr. Rayner made the suggestion that the country might be divided into areas represented by committees voicing the various interests, and this possibly

offers a step by means of which a national organisation might be started.

It may be argued that, at the best, a dual organisation is an unsatisfactory method of solving the problem, and Mr. Coventry took this view in suggesting that the whole organisation might most effectively be placed in the hands of the railways. He pointed out that the latter had the greatest experience of road work of any organisation in the country, and that an analogy with American practice was not necessarily sound, as practice in America was very different from that existing in this country. He expressed the opinion that the proposals outlined in the paper were only an extension of the present railway methods, and that the companies could quite well carry out the proposed services as there were very few places in England which were not near to some line. He added that it appeared very undesirable to maintain the road for heavy traffic at great cost, when the railway lines were already in existence. Following on these suggestions, Mr. H. A. Watson mentioned that the Great Western Railway have been extensively utilising their own road services for a number of years, and that the experience gained by them would be freely placed before any committee appointed to consider the question. On the other side, he mentioned that a feeling existed throughout the country that the railway organisations are already so large that any new developments would be better handled by a different organisation. Mr. Howley, in dealing with Mr. Coventry's suggestion, pointed out that the railway stations were not infrequently too far from the centres of population for the most economic working, and that it would be difficult for the railway companies to approach the figures already attained by some of the road organisations. Passengers were being carried at 1*d.* per mile and goods were being transported at pre-war rates.

Other points referred to by speakers who took part in the discussion were the best design for containers, the difficulty of co-ordinating small country services with the railway schedules, and the unremunerative nature of feeder traffic working at right angles to the railway service.

A vote of thanks to the author was proposed by Sir Henry P. Maybury, who remarked that the days of irresponsible competition must come to an end and that, in the interest of the community as a whole, co-ordination was absolutely essential.

The afternoon session was occupied with visits to the factories of Messrs. J. Lyons and Co., Limited, at Greenford, and to various points on the Watford extension of the Metropolitan Railway.

(To be continued.)

NOTES.

Oil Discharge from Ships.

With the advent of the use of oil as the source of power in naval and mercantile vessels, it became apparent that shore waters were being covered with a film of oil, and in many places the seaside was soon coated with a repellant, black, viscous mass. So great became this nuisance that measures had to be taken to prevent its continuance. In this matter, representatives of most of the shipping interests of the world became associated through the formation of a Committee of the International Shipping Conference to deal with the subject. That the pollution of coastal waters has been arrested through this activity is now apparent, for at the last meeting of the Committee on the 13th inst., a resolution was passed which expressed appreciation of the improvements already effected and testified that the nuisance has, to a large extent, been overcome. The members, however, do not intend to allow interest to slack off, but have resolved to continue their efforts until such times are reached as will permit reconsideration of the whole question. They trust that shipowners will continue their instructions to their ship-masters to take every precaution to prevent any cause of complaint. Much satisfaction may be obtained from the knowledge that the shipping industry showed prompt appreciation of the nuisance and that they have been able to effect a solution which does not interfere with the ordinary course of trade. They co-operated loyally in framing the Oil in Navigable Waters Act, which has since been copied in other countries and has been adhered to rigidly within the three-mile limits of the coasts. Considerable improvement may be expected also from the instructions which are now to be issued by the shipowners of other countries. There are troubles, however, due to the gradual breaking up of wrecks around the coasts, but they are of small numbers, and though pollution due to this cause cannot well be prevented its total effect is but small.

The Opening of Barking Power Station.

His Majesty King George performed the opening ceremony on Tuesday, the 19th inst., of the new electricity supply station at Barking, which has been erected by the County of London Electric Supply Company. The first half of the programme at present in hand has been completed, and plant with an aggregate capacity of 125,000 h.p. is now in position. The engine-room building, which is 300 ft. long and 120 ft. wide, contains four turbo-alternator sets, two being composite sets having a capacity of 50,000 h.p., and the other two are of 25,000 h.p. All the turbines are of Messrs. C. A. Parsons and Co.'s reaction type and run at 3,000 r.p.m., driving three-phase alternators giving a supply at 6,600 volts and 50 cycles. The condensing plant for the turbines was supplied by Messrs. Vickers Limited, of Barrow. At the present time, there are 10 boilers installed, five made by Messrs. Babcock and Wilcox, Limited, and five by Messrs. Yarrow and Co. (1922), Limited. They are designed to work at a pressure of 375 lb. per square inch and with superheat to 700 deg. F. Each boiler has two chain-grate stokers. Eventually in the present boiler house there will be 12 main water-tube boilers and four reheaters for the steam prior to its passage into the low-pressure turbines. In his speech on Tuesday, the King referred to the electrical industry as one of the foremost of our national activities and one which provided the means of improving the conditions of factories and workshops. In the British Isles there seemed to be no insuperable obstacle to the use of electricity on a scale as wide as in many of the Dominions where water power was available. Later His Majesty referred to the difficult problem of co-ordinating the numerous systems of supply in London and the Home Counties, and expressed himself as gratified that the question was approaching solution. It is of interest to note that the County of London Electric Supply Company, which will have perhaps the largest electricity station in the world, is shortly to be placed under the management of Mr. Archibald Page, who has rendered excellent service in dealing with questions of linking-up the supply systems throughout the country during his period of office as one of the Electricity Commissioners.

Architects' Views on the Waterloo Bridge.

The Architecture Club was founded some years ago with the express intention of focusing public attention on the views of established authorities on matters relating to the artistic merits of buildings. The members of the Club are greatly concerned, at present, about the intended demolition of that great example of the work of John Rennie, the Waterloo Bridge. At a dinner which was held at the Hotel Cecil on Friday, May 15, under the chairmanship of Mr. J. C. Squire, many speakers, including the Duke of Atholl, Sir Frank Dicksee, P.R.A., Professor C. H. Reilly and Messrs. E. Crutwell and Harley H. Dalrymple-Hay spoke, in turn, to the effect that it was both desirable and possible to preserve the bridge. The argument appears to be that this structure is so pleasing to the eye that every effort of which man is capable should be used to keep it intact. There seemed also to be a prevailing feeling among some of the speakers that the engineers of this country have proclaimed themselves incapable of preserving the bridge. This notion is much to be regretted, for those who hope to mould public opinion should be completely conversant with the matters on which they speak. We are satisfied that firm contracts would be made by many concerns to preserve the bridge were they solicited. The true position is that the bridge is totally inadequate to deal with the growing road traffic, and also obstructs the river transport. Whatever merits the Rennie bridge, or the one which replaces it, may have to the artistic eye, and we cannot yet be certain that the new one will not be as pleasing as the other, it must be acknowledged that the function of a bridge is to provide facilities for transport. Under present conditions, the bridge must either be widened or replaced. The best thing to do is, undoubtedly, what is proposed, and that is to remove the present Waterloo Bridge. We cannot regard as reasonable the demand that old structures which impede the progress of development of any city should be preserved simply because of their inherent beauty. There were many old and beautiful buildings in London which have been pulled down and replaced by others of little artistic merit, although their preservation would have been possible at little expense. The retaining of the existing Waterloo Bridge is a totally different question, for the expense involved would be out of all proportion to the satisfaction obtained by its repair and maintenance.

The Junior Institution of Engineers.

It must have been apparent for many years to the engineers of this country that the junior associations of members of the profession, of which the Junior Institution of Engineers is the largest and best example, enjoy a popularity which is quite unique. An investigator cannot long remain in doubt as to the reason for this, if he simply visits one of the meetings of the "Juniors." He would be immediately struck with the great spirit of fraternity which is everywhere apparent and prompts even the youngest of the members to give expression to his opinions in the course of the discussions, because he has the knowledge that the older members, though they have greater experience, will never resent the intrusion of one who hopes to learn from a mutual exchange of opinions. In some spheres the young man in quest of information may feel tongue-tied in the presence of authority, but this is not the case in the "Juniors," for there the spirit prevails that youth has a right to be heard. The Junior Institution of Engineers has now reached the mature age of 41 years, but the spirit of youthfulness still prevails and was much in evidence at the Annual Dinner, held on Wednesday, May 13, at the Monico Restaurant, under the chairmanship of the president, Dr. Alexander Russell. In proposing "The Institution" at the dinner, the president-elect, Mr. J. S. Highfield, referred to the history of the society since its foundation in 1884 by a number of apprentices in the works of Messrs. Maudslay, Sons and Field, and also to the many illustrious men who have served in the offices of president and vice-president. In his reply, Mr. H. J. Edgar, chairman of the Institution, spoke of the capacity of their meeting hall being tested to the limit at their weekly meetings. The president of the North-Western Local Section, Mr. A. P. M. Fleming, found scope for an excellent speech on the work of the pioneers of electrical investigation, and afforded Dr. Alexander Russell an opportunity of referring to the great changes made in modern developments in the quest for cheap electrical energy. Air Vice-Marshal Sir W. Sefton Brancker, eulogised engineers for making flying a practical possibility, and expressed the hope that the British Empire, which was built up on a foundation of efficient sea transport, would be maintained through the ages by the excellence of its future air-transport system. Sir Charles L. Morgan also replied for the guests, and a very successful evening was concluded with the testimony of Mr. Hewitson Hall to the value of the work of the chairman, to which Dr. Alexander Russell made reply and expressed appreciation of the services rendered by the secretary, Mr. Herbert G. Riddle.

Physical Chemistry of Steel-making Processes.—It is announced that a general discussion on the physical chemistry of steel-making processes will take place at a joint meeting of the Iron and Steel Institute and the Faraday Society, to be held on Monday, June 8, from 3.30 till 7.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, London, S.W.1.

LABOUR NOTES.

REPRESENTATIVES of the engineering trade unions met in London on Wednesday to hear and consider the decisions of the various executives on the proposals of the Engineering and Allied Employers' National Federation regarding working hours and wages. The following resolution was adopted after discussion:—"That this conference of executive representatives of the unions concerned in the national application for an advance in wages declines to negotiate the wages application on the basis suggested in the Engineering and Allied Employers' National Federation letter dated April 22, 1925." The effect of this decision is to revert to the position which obtained in the earlier conferences with the employers, viz., that working hours, night shifts and overtime, being the subject of separate agreements, should be considered apart from wages, and that in dealing with them the procedure set up for the adjustment of differences should be followed. What the employers may do in these circumstances is not easy to foretell, as they have all along very properly contended that only through some such modifications as they have suggested can the industry be made capable of yielding higher earnings to the workers. Mr. Brownlie, the president of the Amalgamated Engineering Union, stated at the close of Wednesday's conference, that there was "complete and emphatic unanimity" in the meeting against the proposed extension of the working day.

The Ministry of Labour Gazette states that employment showed little change, on the whole, during April. Among the 11,500,000 workpeople insured against unemployment under the Unemployment Insurance Acts in Great Britain and Northern Ireland, the percentage unemployed at April 27, 1925, was 11·2, compared with 11·4 at March 23, 1925, and 9·7 at April 28, 1924. Among the members of those trade unions from which returns were received the percentage unemployed was 9·4 at the end of April, 1925, compared with 9·0 at the end of March, 1925, and with 7·5 at the end of April, 1924. Employment was good, on the whole, with coachbuilders and brickmakers, with most of the skilled operatives in the building trades, in the jute trade, and in some branches of the cotton trade; it was fairly good with millsawyers and brushmakers, in the furnishing and carpet trades, and in some sections of the metal trades. In the wool textile industry, in coal mining, in the iron and steel industry, in tinplate and steel-sheet manufacture, in the marine and heavy engineering trades, and in the shipbuilding industry employment was bad.

There was little net change in rates of wages during April. In the industries for which statistics are regularly compiled by the Ministry of Labour, the changes reported resulted in an aggregate increase of 10,400*l.* in the weekly full-time wages of 410,000 workpeople, and in an aggregate reduction of 9,000*l.* in the weekly wages of nearly 180,000 workpeople. The principal group of workpeople whose wages were increased consisted of coal miners in Yorkshire and the East Midlands, where the percentage addition to basis rates was slightly raised (by the equivalent of less than 0·1 per cent. on current rates) and special "subsistence" allowances, ranging up to 6*d.* per day, were granted to the lower-paid men. There was also a small increase in the wages of coal miners in the Radstock district. Other workpeople who received increases included cement workers and compositors employed in provincial daily newspaper offices in England and Wales. Among the workpeople whose rates of wages were reduced were iron puddlers and millmen in the Midlands, who sustained reductions equivalent to about 1½ per cent. on current rates, and workpeople employed in the textile bleaching, dyeing, &c., industry, who had their wages reduced by about 2½ per cent. on current rates in Yorkshire, and by 1*s.* 3*d.* or 1*s.* 4*d.*, and 10*d.* per week in the case of men and of women respectively in Lancashire and Scotland. Other groups of workpeople whose wages were reduced included ironstone miners in Cleveland, steel-sheet millmen and galvanisers, iron and steel workers in South Wales and Monmouthshire, blast-furnace workers in several districts, woollen and worsted operatives at Leicester, felt-hat makers, and workpeople employed in the seed-crushing and oil-milling industry.

The number of trade disputes involving stoppages of work reported to the Ministry of Labour as beginning in April was 44. In addition, 26 disputes which began before April were still in progress at the beginning of the month. The number of workpeople involved in all disputes in April (including workpeople thrown out of work at the establishments where the disputes occurred, but not themselves parties to the disputes) was about 25,000; the estimated aggregate duration of all disputes during April was about 122,000 working days. These figures compare with totals of approximately 44,000 workpeople involved and 161,000 days lost in the previous month. The aggregate duration of all disputes in progress in the first four months of 1925 was about 444,000 working days, and the total number of workpeople involved in these disputes was 80,000. The figures for the corresponding period of 1924 were 2,551,000 days and 326,000 workpeople respectively.

During the first four months of 1925 the changes reported to the Ministry of Labour, in the industries for which statistics are compiled, have resulted in net increases amounting to 72,000*l.* in the weekly full-time wages of 735,000 workpeople, and in net reductions of 29,500*l.* in those of 650,000 workpeople. In the corresponding period of 1924 there were net increases of over 230,000*l.* in the weekly full-time wages of 1,800,000 workpeople, and net reductions of 37,500*l.* in the weekly wages of nearly 680,000 workpeople.

At the end of April, 20,175 members of the United Society of Boilermakers and Iron and Steel Shipbuilders were "signing the books," as compared with 22,567 at the end of March. The expenses in March were 96,456*l.* 16*s.* 5*d.*; in April, they amounted to 89,359*l.* 15*s.*

In the report of the General Federation of Trade Unions for the first quarter of the current year, Mr. W. A. Appleton, the secretary, states that the finances of the organisation are recovering from the post-war pressure. A reserve of 150,000*l.* cannot, he admits, be said to be entirely satisfactory; but it is something, he claims, to be thankful for in view of the hard times through which all trade unions have passed. Mr. Appleton mentions, by the way, that information has reached the Management Committee of the Federation to the effect that in some parts of the country employers are showing a tendency to secede from the Industrial Councils. This tendency should, he says, be noted and guarded against. If these Councils are to be weakened by secessions on the part of employers, it may mean, he suggests, that more direct and forceful methods of dealing with disputes are contemplated. Such a course might not, it is added, make for industrial peace, and would be regrettable; but the suggestion should warn the unions to make the best possible financial provision against unjustifiable attacks.

A statement issued last week by the joint-committee appointed by the Mining Association and the Miners' Federation to investigate the economic position of the coal industry contained some interesting information about German wages and output. Figures were put forward by both sides, and there was no appreciable difference between them. Attention was, it is stated, chiefly directed to the following:—

Germany—Ruhr District.

	Third Quarter, 1913.	Third Quarter, 1924.
Earnings per shift	5·42 marks (5/3·67d.)	6·24 marks (6/4·80d.)
Output per person per shift	0·92 English ton	0·88 English ton
Standard price (bituminous unscreened)	12 marks	—
Wages cost per ton ..	6 marks (5/11·5d. per English ton)	—

It was pointed out that although the output per person per shift (surface and underground) shows a reduction of 4·72 per cent. as between 1913 and 1924, the output per person at the face (*i.e.*, hewers and putters) shows an increase of 1·75 per cent. The wages cost is about 50 per cent. of the total cost in Germany, as against 70 per cent. in this country, and while earnings and wages cost are less in Germany than here, the various items of costs other than wages are higher, both absolutely and also when expressed as a percentage of the total. Particulars were also given showing that the deductions made from the wages quoted above for various insurances amounted, in the case of the hewer, to as much as 10½*d.* per shift, and in the case of the surfacemen 9*d.* per shift. Attention was called by the owners' side to the extraordinarily large amount of 1*s.* 3·88*d.* per ton included in the statement of costs of production under the heading of wear and tear, and to the German figure of colliery consumption amounting to 9 per cent. of the output at German collieries, as compared with 6 per cent. in this country. The chief points raised by the workmen's side on these figures were that the increase in the cost of living was not so great in Germany as in this country, and that they could not believe that the item of 1*s.* 3·88*d.* per ton for wear and tear only included the equivalent of replacements and depreciation, amounting to 5*d.* per ton in this country. Reference was made to the great increase in the production of brown coal in Germany (124,000,000 tons in 1924, as compared with 87,000,000 tons in 1913), which enters into competition with German black coal and thus intensifies the competition with British coal.

According to cabled news from Australia, the Bill to amend the Federal Arbitration Act has now been drafted. It is proposed that the Court shall have increased power (1) to enforce its awards, (2) to compel trade unionists to respect the awards, (3) to deal with individuals as well as with groups of employers and employees, and (4) to subject the funds of the unions to supervision as in the case of Friendly Societies. The measure also seeks to invest trade unions with the rights and status of corporations with equal responsibilities, to empower the Court to deal severely with agitators and strifemongers, and to make trade unionism compulsory as far as circumstances permit.

Owing to continued ill-health, Mr. A. G. Cameron has decided to give up the position of General Secretary of the Amalgamated Society of Woodworkers on June 30 next. Mr. Cameron was appointed London organiser of the old Amalgamated Society of Carpenters and Joiners in 1913, and became Assistant General Secretary two years later. On the formation in 1919 of the Amalgamated Society of Woodworkers by the amalgamation of the Amalgamated Society of Carpenters and Joiners, the Associated Society of Carpenters and Joiners, and other woodworking organisations, he was appointed General Secretary.

The Ministry of Labour states that on May 11, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,184,200—905,800 men, 36,200 boys, 209,600 women, and 32,600 girls. On May 4, 1925, the number was 1,180,479—903,807 men, 36,262 boys, 207,452 women, and 32,958 girls—and on May 12, 1924, it was 1,026,138—760,561 men, 35,704 boys, 196,137 women, and 33,736 girls.

The difference regarding shopmen between the National Union of Railwaymen and the craft unions appears to be as far off adjustment as ever. Some time ago, it will be recalled, the Railway Staffs Conference suggested that the N.U.R. might take the initiative in securing a conference on the subject with the craft unions, undertaking to set up suitable machinery for dealing with the shopmen's claims if there were agreement between the two groups to utilise it. The N.U.R. accordingly communicated with the other organisations, but apparently without success. A summary of the correspondence appears in *The Railway Review*, which comments on the matter as follows:—

"In certain directions it is suggested that the question of organisation should first be settled and then a conference may possibly be called. This question of organisation has been the subject of conferences between the organisations and through the Trades Union Congress General Council for the past twelve years, and even the recent attempts of the latter body have proved fruitless. Despite that and the readiness of the N.U.R. to consider the immediate interests of the men, apart from the method of organisation, the answer to the N.U.R.'s request is the contrary to what the men throughout the country expect.

"Well, the craft unions must take the responsibility for their actions! The National Union of Railwaymen has made every effort to secure joint consideration, and its failure in this respect must lie at the door of those who prefer to allow the subject of method or organisation to operate before the immediate interests of those concerned, *i.e.*, working conditions. At the present rate of progress the method of organisation will soon solve itself, because there is a steady influx of membership into the N.U.R. of all sections of shopworkers.

"Certain it is that with the overwhelming majority of shopmen within the ranks of the National Union of Railwaymen, the union does not intend to allow those members to suffer by reason of mere quibblings as to which organisation particular individuals shall belong. Rather must it pursue its way, and in doing so know that the greater number, including many at present members of craft organisations, are behind it in its efforts to secure stabilised machinery and conditions for all those employed in the service."

PRODUCTION OF IRON AND STEEL IN APRIL.—The National Federation of Iron and Steel Manufacturers, of Caxton House, Tothill-street, Westminster, London, S.W. 1, announces that the production of pig-iron in April amounted to 569,800 tons, compared with 607,900 tons in the previous month. Included in the production were 187,400 tons of hematite, 188,500 tons of basic, 138,200 tons of foundry, and 23,200 tons of forge pig-iron. There were 11 fewer furnaces in blast—namely, 158—at the end compared with the beginning of April. The production of steel ingots and castings in April amounted to 597,500 tons, compared with 684,700 tons in March. Imports of iron and steel during the month amounted to 274,000 tons, the record figure since May, 1924.

VULCAN TWO-TON ROADLESS VEHICLE.

THE vehicle which we illustrate in the accompanying figure has been designed by the Vulcan Motor and Engineering Company (1906), Limited, of Southport, for use in roadless country. When fitted with a lorry body it will carry a useful load of 2 tons, and on reasonable surfaces will haul one or more trailers with an additional load of from 4 tons to 5 tons. An unusual feature for a vehicle of this type is that a quick-change attachment enables it to be fitted with wheels for ordinary road operation whenever required.

The track, which is generally of the Kegresse system, is manufactured under licence from the Roadless Traction Company, and represents the latest development in this direction. The drive is transmitted from the sprocket wheels on the back axle by means of the endless track seen in the illustration. The track is made up of stamped-steel links having automatically lubricated spherical joints, which are designed to permit of cornering without drag on the road surface, a radius of 17 ft. being easily taken. The two four-wheel rubber-tyred bogies run on the inside of the endless tracks, and are fixed to the bogie brackets by means of spherical joints of large diameter, which ensure the requisite universal motion. The forward end of the bogie frame carries the idler wheel on an adjustable arm. The idler wheels are fitted with rubber tyres to ensure quiet running of the endless track.

The engine is a four-cylinder model of 95 mm. bore by 130 mm. stroke, giving an R.A.C. rating of 22·4 h.p. It is fitted with a large-diameter hollow crankshaft, through which the journal and big-end bearings are lubricated from an oil pump of the gear type. Pump circulation of the cooling water is employed, the radiator being of the gilled-tube type. A cone clutch is fitted, faced with Ferodo, the springs being adjustable. A flexible-disc universal joint is provided between the clutch and the gear-box, and the drive from the latter is by an open tubular propeller-shaft fitted with a cross-pin type of universal joint. The gear-box has central gate change, and is fitted with four forward speeds and reverse. The ratios are 10·3, 15·9, 26·3 and 69 to 1, the reverse being 115 to 1. The driving axle is fitted with overhead worm and wheel, giving a reduction of 10·3 to 1. The differential is of the spur-wheel type, and the final drive is transmitted through high tensile-steel shafts to the driving sprocket wheels, which run on removable bronze floating bushes.

The frame is a deep channel-section pressing in nickel steel with substantial cross-members, and is provided with a draw-bar attachment. Both front and rear springs are of the semi-elliptic type. Two independent braking systems are provided, the foot pedal operating a locomotive-type brake mounted behind the gear-box, and the hand lever, internal-expanding brakes with 18-in. diameter drums on the rear wheels. Steering is by worm and wheel. The wheelbase is 9 ft. 7½ in., the track 4 ft. 11½ in., the overall length 19 ft. 2½ in., and the overall width 6 ft. 5½ in. The chassis weight unladen is 3 tons 1¼ cwt.

PERSONAL.—It is announced by the Ministry of Transport that Mr. Archibald Page has been asked to become a Director and General Manager of the County of London Electric Supply Company. He has consequently tendered his resignation as a member of the Electricity Commission. The Minister of Transport has invited Mr. S. L. Pearce, C.B.E., to become an Electricity Commissioner, and, subject to the agreement of the Manchester Corporation to release him from his present office, Mr. Pearce has signified his willingness to accept the post.

CONTRACTS.—It is announced that Sir W. G. Armstrong Whitworth and Co., Limited, of 8, Great George-street, Westminster, London S.W.1, have secured a contract from the Mersey Docks and Harbour Board for the supply and erection of three pairs of steel gates for use at the river entrance at the Alfred Dock at Birkenhead.—Messrs. Howden Ljungström Preheaters (Land), Limited, of 133, Helen-street, Govan, Glasgow, have received an order for a preheater from Messrs. John Galloway and Co., Limited, of Balerno Mills, near Edinburgh.—The Brightside Foundry and Engineering Company, Limited, colliery and general engineers, of Sheffield, have secured an order for the supply of a hydraulic decking installation, including electric motor equipment for service at the South Yorkshire coal field.—The D.P. Battery Company, Limited, of Bakewell, Derbyshire, has secured an order from The Aberdeen Corporation Electricity Department for the replating of the Ferryhill generating station battery, at a cost of, approximately, 8,000l.—Messrs. James Pollock, Sons and Co. Limited, of 3, Lloyd's-avenue, London, E.C.3, have secured a contract for a motor tug for use on the River Thames, having a length of 66 ft. 6 in., a breadth of 16 ft. and a draught of 6 ft. The vessel will be constructed at the company's Faversham Yard. Orders have also been received for a 140-ft. long passenger and cargo vessel for service in the Far East, and a twin-screw motor vessel for special service abroad. "Bolinder" engines will be installed in each case.

TWO-TON ROADLESS VEHICLE.

THE VULCAN MOTOR AND ENGINEERING COMPANY (1906), LIMITED, SOUTHPORT.

ENGINEERING TRAINING AND EDUCATION.

British Electrical and Allied Manufacturers' Association Scholarships.—Notice has been given by the British Electrical and Allied Manufacturers' Association that applications for the educational scholarships, session 1925–26, should be received not later than June 1, and applications for renewal of scholarships not later than July 1. Full particulars of the scholarships may be obtained by writing to the Secretary of the B.E.A.M.A., 36, Kingsway, London, W.C. 2.

CATALOGUES.

Thermometers.—A card list of standard patterns of dial thermometers is to hand from the Cambridge Instrument Company, Limited, 45, Grosvenor-place, London, S.W. 1.

Induced Draught.—The "Sureal" induced draught apparatus is illustrated in a leaf catalogue received from Messrs. James Pollock, Sons and Co., Limited, 3, Lloyd's-avenue, London, E.C.3.

Name Plates.—The Stimur Manufacturing Company, Macdowall-street, Paisley, have sent us circulars of aluminium plates embossed with street names, numbers, general directions, notices, &c.

Aero Engines.—The Aircraft Disposal Company, Limited, 89, Kingsway, London, W.C. 2, have issued some particulars of the 240 h.p. Siddeley-Puma engine of which they have a stock ready for delivery and an adequate quantity of spare parts.

Bath Fittings.—Messrs. Ewart and Son, Limited, 305, Euston-road, London, N.W. 1, have issued a circular illustrating their brass taps, unions, overflow and waste fittings for baths, the exposed parts of which are covered with white porcelain enamel.

Electric Motors.—A list of standard direct-current motors and generators from ¼ h.p. to 25 h.p., with tables of speeds, outputs and prices, has been received from the Globe Engineering Company, Limited, 48, Watling-street, London, E.C. 4.

Drying Rooms.—Illustrations of laundry drying rooms fitted with air heaters, conveyors, and automatic grip-and-release mechanism are given on a wall-sheet received from Messrs. Manlove, Alliott and Co., Limited, Nottingham.

Mine Signalling.—Messrs. Siemens Brothers and Co., Limited, Woolwich, London, S.E. 18, have sent us a revised issue of their catalogue of mine-shaft signalling apparatus, which has been in use extensively for some years.

Pneumatic Tools for Road Making.—A catalogue of pneumatic tools for shovelling, tamping, digging, and breaking up concrete in road-making work, has come to hand from the Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, London, W. 1. The use of these tools appears to be extending rapidly.

Omnibus Bodies.—A catalogue of the coachwork of omnibuses of the petrol-motor and railless-electric types, some having covered top decks, has come to hand from the Brush Electrical Engineering Company, Limited, Loughborough. The illustrations show examples actually supplied and in service in various parts of the country.

Wrought Iron.—The Council of British Wrought-Iron Associations, Atlantic Chambers, Brazennose-street, Manchester, have issued a pamphlet giving reasons for specifying wrought-iron for various purposes and illustrating structures which prove the durability of this material.

Shearing Machines.—A catalogue of heavy machines for cutting up scrap, shearing billets and slabs and cutting and punching plates is to hand from Mr. Henry Pels, 40 Great Marlborough-street, London, W.1. These machines are very powerful and are constructed for rapid and heavy work.

Electrical Machines.—Messrs. Brown, Boveri and Co., Limited, Baden, Switzerland, have sent us a copy of the March issue of their monthly periodical, printed in English containing articles dealing with tests of transformers, the starting of rotary converters and fuel economy in steam power stations. Their London office is at Trafalgar House, Waterloo-place, S.W.1.

Electric Motors and Generators.—Two catalogues of continuous-current motors and generators, with illustrations of parts and full tables of powers, dimensions and weights, has been received from the Ateliers de Constructions Electriques de Charleroi, of Charleroi, Belgium. One of these catalogues deals with protected fan ventilated machines and the other with the totally enclosed ventilated type. The London Office of the Company is at 56, Victoria-street, S.W.1.

Boiler Furnaces.—Murray fin tubes are water tubes placed vertically round the walls of the combustion chambers of water-tube boilers, in front of the firebrick surface. There are two fins diametrically opposite and the fins of adjacent tubes overlap, forming a shield for the firebrick when tubes, which are 4 in. in diameter, are placed about 3 in. apart. The object is to increase the heating surface and to absorb the radiant heat. A catalogue issued by the Underfeed Stoker Company, Limited, Aldwych House, Aldwych, London, W.C. 2, illustrates the tubes and their application and also contains figures of tests showing the economy obtained.

Special Steels.—Messrs. Edgar Allen and Co., Limited, Sheffield, have sent us three catalogues containing much useful information on the subject of special steels. The first deals with the permeability of steel castings for electro-magnets, illustrating three motor castings ranging from 3½ cwt. to 47½ cwt. in weight, and giving curves for two different materials. The second publication is a new edition (the 6th) of the firm's catalogue of railway switches and crossings, giving full technical particulars required by permanent-way engineers for designing and ordering material. The third catalogue is of a more general character, dealing with motor casings, railway wheels, road wheels, valve bodies, hydraulic cylinders, dredger parts, toothed wheels of many kinds, and also with small castings such as links, chains, spanners, brackets, &c. All these catalogues give clear and useful technical information such as engineers will be glad to have at hand for reference.

LARGE TELEPHONE BATTERIES.—Four unusually large electric storage batteries are being supplied by the Chloride Electrical Storage Company, Limited, of Clifton Junction, Manchester, to the Automatic Telephone Manufacturing Company, Limited, of Milton-road, Liverpool, for the mechanical tandem exchange and Strowger automatic telephone exchanges at Holborn, London, which the latter firm is equipping. Each cell is 5 ft. 8 in. in length, 1 ft. 8 in. in width, and 5 ft. in height. There are 35 positive plates and the total weight of each cell, including the electrolyte, is over 2 tons. Wood containers lined with lead, and mounted on stoneware supports, accommodate the plates which are 2 ft. 3 in. in height and 1 ft. 2 in. in breadth. All plates of common sign are burned to heavy lead connecting bars fitted with suitable terminal cups at the ends of each battery, to which the main copper bus-bars will be attached. The capacities of the cells are 8,400 amp.-hrs. discharging in 5 hours to 1·85 volts and 9,870 amp.-hrs. discharging in 9 hours to 1·83 volts per cell. Stoneware pedestal cell supports will be used.

"FLAKES" OR "HAIR-CRACKS" IN CHROMIUM STEEL, WITH A DISCUSSION ON "SHATTERED ZONES" AND "TRANSVERSE FISSURES" IN RAILS.*

By AXEL HULTGREN, Met. Eng.

A DEFECT known as *snow-flakes* or *flakes* (America), *hair-cracks* or *hair-lines* (Great Britain), *Flocken* (Germany), and *cassures ligneuses* (France), has received much attention among manufacturers and inspectors of alloy-steel forgings, particularly during the war. This defect has the appearance of approximately circular, bright, coarsely crystalline spots of varying size (from 2 to 20 millimetres), which may be seen in the fine-grained fracture of the heat-treated forging. It may also appear as lines without appreciable width on machined or polished surfaces.

A defect in every way similar to the one described has been noticed from time to time in the manufacture of ball and roller bearings at the works of Aktiebolaget Svenska Kullagerfabriken (SKF), in Gothenburg. The steel used has the following composition: Carbon, 1·0 per cent.; chromium, 1·5 per cent.; silicon, 0·25 to 0·35 per cent.; phosphorus and sulphur together, less than 0·045 per cent.

Flakes have been found in forged rings of larger sizes, about 400 millimetres outer diameter and upwards, and in heavy rolled or forged bars above 60 millimetres in diameter. Obviously, objects of larger section are more susceptible to flakes than smaller ones.

The rings and discs were hardened in water. For a special purpose, large rings have been made from a steel of the composition: Carbon, 0·70 per cent.; chromium, 1·0 per cent.; manganese, 1·0 per cent. in this case the rings being hardened in oil. Some of these rings also cracked in hardening, showing flakes in the fracture.

In all cases, the flakes have been easy to recognise as such on account of their bright, coarsely crystalline appearance, contrasting with the surrounding silky fracture of the hardened steel. Examples are shown in Figs. 6 and 7. The flake areas are generally roughly circular, of a size varying from about 2 to about 20 millimetres. When present in large rings machined from ring forgings, they were found somewhere in the central zone of the section. In the case of outer and inner rings being trepanned from the solid bar, flakes were found in inner rings only. In that case it might happen that the flakes extended to the surface of the ring, hence oxidation during heating was made possible. As a result, the flake in the fracture might appear as a black area. For these and other reasons it was considered that flakes were actual cracks existing before heating for hardening. The plane of the flake was always found to be parallel with the geometrical axis of the bar or ring, the orientation being usually approximately radial.

Fig. 5.

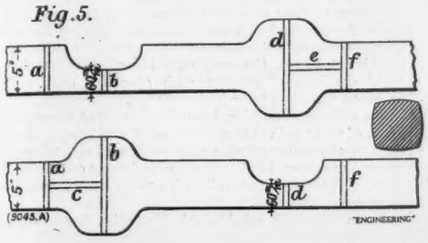


FIG. 6.

FIG. 7.

FIGS. 6 AND 7. Fractures of Hardened Disc from 160 mm. Forged Bar. × 1·3.

The quality of the steel has been repeatedly made responsible for the formation of flakes. For this reason the following data may be of interest: The steel here considered is made from very pure Swedish raw materials. The open-hearth charge is made up exclusively of charcoal pig-iron and chromium-steel scrap of the firm's own manufacture, including oily turnings, the latter up to 10 per cent. of the total charge. The furnace capacity is 15 tons, and the ingots, weighing 560 kg., are top poured, with a feeding box 12 in. square at the top, big end up. Apart from routine microscopical examination, constantly employed, the quality of the steel has been and is repeatedly tested by endurance tests on ball bearings, carried out in the Gothenburg Laboratory. Further, in microscopical examination of specimens containing flakes, on several occasions it has not been possible to establish any connection between the presence of flakes and any unusual amount of inclusions, nor to trace the actual line of a flake, as seen in the section, through any large group of inclusions. The flake may be found to pass through a group of inclusions, but the latter were never found to be prominent.

In trying to solve the flake problem, it appeared to be of primary importance to ascertain at what stage in the sequence of manufacture the cracks form. It has been stated that the defect has its origin early in the history of the metal. The present author, however, from observations made, formed an opposite conception. If flakes started as cracks in the ingot, it did not seem plausible, whatever shape they might have had originally, that, after the deformation in rolling or forging, the flakes would be roughly circular, as was actually found in the chromium steel bars and rings. Furthermore, slight hot-working is sufficient to weld flakes together completely.

Accordingly, the present investigation was started—in July, 1924—on the hypothesis that the flakes formed during the last hot-working operation.

Distribution of Flakes in Sections of Billets.—For the detection of flakes the following procedure was adopted:—

The discs, which are ground on emery paper on one side, are placed with this side up on the poles of an electro-magnet, in such a way that the lines of force traverse the central part of the section. The whole is arranged in a tilted position, the inclination of the section to be examined being about 15 deg. to the horizontal. A suspension of very fine steel grindings in gasolene is slowly poured on to the top part of the specimen. In streaming down the steel surface the steel dust collects on all cracks present, except on those that run parallel with the lines of force. By turning the disc into various positions and repeating the test, a position is usually found in which all cracks present are revealed, or else the absence of cracks is proved.

Two of these specimens are shown in Figs. 9 (*a*) and 9 (*b*), on page 650. From this series it was concluded, tentatively, that during rolling, in the last pass or the last two passes, the secondary tension, set up in the billet in consequence of the lateral spread, caused the interior to split up, the cracks following the vertical diagonal.

Forging 130-mm. Round Bar from Billet.—A billet 145 mm. square was first forged in successive steps to 130 mm. round in one end. Then the other end was forged in the same way, the first direction of forging being at right angles to that of the other end. The bar was then annealed, and two discs were cut from each stage of forging.

On examining the discs in the manner described above, flakes were found to be present in the centre of the billet, of approximately diagonal orientation. The flakes seemed to disappear gradually during forging. It could not be stated with certainty whether any new flakes formed meanwhile. The net result was that the finished bar contained small flakes in the centre of one end, whereas flakes were absent in the other.

Forging Large Rings on Mandrel.—It was above all desired to get rid of flakes in large ring forgings. Numerous experiments in forging large rings were therefore made from ingot sections, using a 2-ton steam hammer.

The rings were made in five forging operations, and, before each forging operation, the blank was reheated. The reheating temperature lay between 1,025 deg. C. and 1,150 deg. C., and during each forging operation the temperature fell to between 700 deg. C. and 850 deg. C. Ingots from a single open-hearth heat were selected for this series. During these experiments the following processes were intentionally varied:—

After forging, the rings were cooled down on the floor, then annealed at 790 deg. C., allowed to cool, hardened in water from 810 deg. C., and finally broken into at least eight pieces under the hammer. Most of the rings contained flakes; although some did not, there is no single condition, of those studied, that has given consistently good results, except possibly reduction in width of section.

In this state of affairs the matter was reconsidered. Obviously, the conflicting character of the results obtained up to this point indicated that the factor constituting the real, or perhaps the predominant, cause of flakes had not yet been put to the test. The hypothesis followed that flakes formed in the final hot-working operation did not appear to be correct. The conclusion that the determining factor, after all, was to be sought for "early in the history of the metal" was close at hand, but nevertheless was rejected, for the reason that all evidence regarding the distribution of flakes, as it accumulated, led more and more to the opposite view. In Figs. 10A and 10B (page 651) are shown central sections parallel to the sides of the ring taken from annealed ring fragments, and treated by the magnetic method. It is seen that most of the cracks were approximately radial. Some cracks had a definite orientation to the flats and impressions formed on the outer and inner ring surface during the final forging operation. From this the idea of a close connection

* Paper read before the Iron and Steel Institute, London, on May 8, 1925. Abridged.

between this operation and the formation of flakes was strengthened.

During all the experiments made up to this point, one factor was consistently neglected, the rate of cooling after forging. This was tested in the following series :—

Large Ring Forgings. Different Rates of Cooling.—Five rings were forged in the ordinary way, the heating also being normal. The first four, immediately after forging, were laid on the floor and covered with charcoal dust. The fifth ring was allowed to cool on the floor without any cover. The first four rings contained no flakes, but the last one broke in hardening, through flakes. Numerous flakes were present in all fractures.

It was inferred that the flakes form during cooling after forging, and that they can be prevented by retarding the rate of cooling. In order to confirm these conclusions it was considered unnecessary to spend more time and money on expensive large forgings. Further tests were therefore made on bars.

Local Forging. Rapid Blows.—One 5-in. square billet was, in one heating, forged down locally at both ends, as illustrated by Fig. 5, on page 649. The blows were applied as fast as the hammer would work. The billet was then left to cool in the air. After annealing, slabs were taken out as indicated in the figure and examined for flakes. Flakes were found in the slabs *b* and *d* in the central portion, lying parallel to the flat surface. The other slabs were free from flakes. The direction of the flakes, in this case, is unusual, but may be explained tentatively as follows:—The thin, forged-down part of the billet cooled faster than the adjacent parts of heavier section. The contraction of the former during cooling was, therefore, to some extent, resisted by the latter, tension being set up at right angles to the forged surface, thus giving rise to cracks parallel to the surface.

Six other 5-in. square billets were forged in a similar way, one end being heated to a high temperature and the other end being kept rather cold. In addition, the end forged last, either hot or cold, was buried in charcoal dust after forging. In this way four different combinations of conditions were tested. After annealing, slabs were taken as described; all were free from flakes. It is probable that, due to the cover which extended over the greater part of the billet, the cooling of the uncovered end was sufficiently retarded to prevent the formation of flakes.

One End Cooled in Air; the Other Buried.—Three 160-millimetre round bars were forged from 8-in. square billets. After reheating and forging one end, the other end was placed in the furnace, the first end cooling in the air meanwhile. Finally, the second end was forged, and allowed to cool under cover of charcoal dust. After annealing, two discs were cut from each end of each bar. One of them was hardened and fractured; the other examined by the magnet test. While the air-cooled ends contained flakes, none of the latter were found in the buried ends.

Normal and Low-Temperature Rolling. Various Rates of Cooling.—Slow cooling prevented formation of flakes. Cooling in air-blast did not seen to produce more flakes than cooling in still air. In the present case, low reheating temperature was favourable, but further experiments are needed to settle this question, since previous experience seems to point in the opposite direction.

Further Tests on Rolled Bars.—Out of one hundred 109 × 109 millimetre billets, thirty were cooled on the floor and seventy buried in charcoal dust. From each billet a thick disc was cut off with the oxy-acetylene flame. These discs were annealed, and thin discs cut out clear of the cut surface. The discs were hardened and fractured. Of the thirty air-cooled billets three showed flakes; all slowly-cooled billets were free from flakes.

Out of twenty-one rolled bars 93 millimetres in diameter, eleven were cooled in air and ten buried in charcoal dust after rolling. Upon disc inspection, all of the former were found to contain flakes, whereas the latter were free from flakes.

When billets have had one end cut off with the oxy-acetylene flame, for seaminess or some similar defect, it has been observed several times that the blank taken close to the cut end in forging is liable to develop cracks, and, consequently, has to be discarded. The explanation was furnished when a bar, 2 in. round, cut in this way, was tested by disc inspection after annealing. The disc, taken close to the cut end, was hardened and broken. The fracture showed two unmistakable flakes, about 11 × 4 millimetres, at a distance of 1·5 millimetre from the cut surface. New discs taken from the bar showed no flakes.

The question whether flakes are inter- or intracrystalline has been discussed. Since such terms may refer to the dendrites of the ingot, which are deformed during hot-working, or to the actual crystal grains of austenite at high temperature, or of ferrite, pearlite, or sorbite at lower temperatures during forging and rolling operations and subsequent coolings, it is obvious that they should not be used without qualification. That the flakes have no consistent orientation to the dendrites of the ingot, in the cases here studied, is clear from the close relation between the orientation of the flake planes, and the manner in which the final hot-working was carried out.

The flakes form during cooling after hot-working; at what stage the author has not yet been able to determine. From an analysis of cooling stresses, it appears probable that the cracks are formed after the central portion has cooled down appreciably, consequently after the Ar1 transformation is passed.

The microstructure of this steel, after hot-working and cooling in air, is seen in Figs. 12 and 13. The previous austenite grains are sometimes, but not always, separated by a thin network of cementite. Each austenite grain has transformed into a great number of grains or colonies of sorbite and lamellar pearlite. The dark lines are cracks or flakes. It is seen that their width is not measurable at this magnification (× 1,000). From these photographs it may be concluded that the cracks follow mainly the austenite grain boundaries, but sometimes deviate and pass arbitrarily through pearlite and sorbite grains.

It was to be expected that retarded cooling after hot-working, introduced to prevent the formation of flakes in large bars and forgings, would cause difficulties in annealing. In fact, it has been found at Hofors that if the bars after rolling are buried immediately, the usual annealing practice for such steel will fail to produce the desired softness—less than 200 Brinell—and annealing structure. If, however, the bars are allowed to cool in the air down to an estimated temperature of about 750 deg. C. and are then buried, the annealing result becomes normal, a hardness of about 180 Brinell and a granular pearlitic structure being obtained. Furthermore, it has been found unnecessary completely to cover the bars with charcoal dust. The present practice is to place first one layer of bars closely together, as they come from the mill, on a bed of ashes that forms part of the mill floor. On the first layer are then placed one or two additional layers, the ends only being protected from rapid cooling by contact with charcoal dust. No cover on the top seems to be needed.

Since the introduction, in the beginning of November, 1924, of retarded cooling after rolling and forging larger sizes of chromium steel, no flakes have been detected. From November, 1924, up to the beginning of February, 1925, 112 tons of rolled bars 75 to 113 mm. diameter have been inspected.

From the fact established, that the formation of flakes is prevented by suitably retarding the rate of cooling after hot-working, it follows that the flakes are mainly due to the cooling stresses that develop as a result of the differential rate of cooling in the exterior and interior portions of the object. The manner in which the last hot-working operation is performed has been found to affect the distribution of flakes formed. It is concluded, therefore, that the cooling stresses induced in the interior of the metal are superimposed upon stresses remaining from hot-working. At a given moment there will be, at every point, a resultant main stress of given direction and magnitude. During the course of cooling, this stress will vary with the temperature, and so also will the cohesion of the metal. If at any time in some point in the mass of the steel the curve of varying stress intersects the curve of varying cohesion, a crack will start and spread instantaneously, probably at right angles to the resultant main stress, until the stress is sufficiently relieved. In this way the roughly plane shape of the flakes is accounted for, and also their regular distribution approximately at right angles to the internal tension induced in the last hot-working operation.

It may be added that the distribution of cooling stresses, to a great extent, depends upon the shape of the object. In a perfect sphere or cylinder, the external metal would form, so to speak, a continuous arch unable to yield when subjected to tension from the interior during the later stage of cooling. In a square or flat object, in this period, the sides will be forced to bulge inwards somewhat, thus causing some relief to the stresses. At that time, however, the peripheral metal is probably fairly cold and rigid, and is consequently unable to yield sufficiently permanently to prevent cracking in the interior.

Experience has shown that the size of the object has great influence on the formation of flakes, larger objects

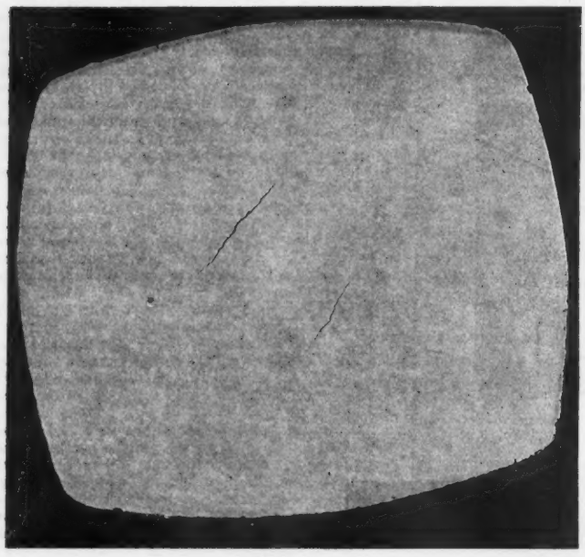


FIG. 9A.

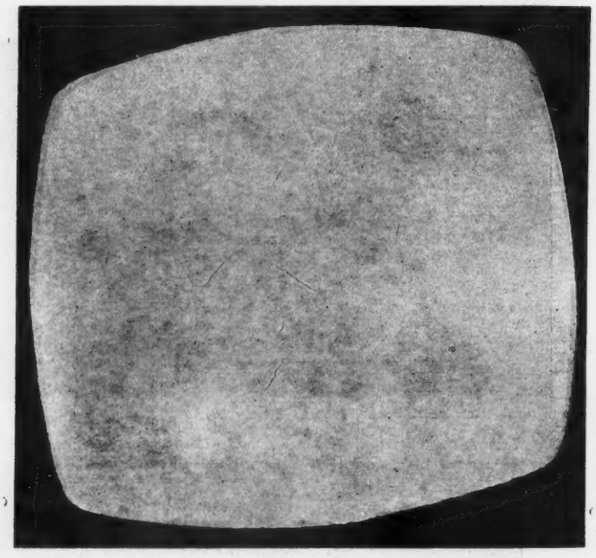


FIG. 9B.

FIGS. 9A AND 9B. Sections of 95 × 95 Mm. Billets. Polished with Emery Paper. Treated with Iron Dust on Magnet. × 1·5.

being more susceptible to this defect. In large objects, the maximum difference in temperature which is reached between surface and interior during the cooling period is greater than in small objects. Thus, in the first stage of cooling, a greater amount of permanent stretching is forced upon the peripheral metal from the interior which is still hot. In the second stage of cooling, after the stresses have reversed themselves, the tension in the interior will, in consequence, be greater. The smaller the heat conductivity, the steeper the temperature gradient during cooling. Therefore, dangerous cooling stresses may form in objects of smaller size than would otherwise be the case. This may be one reason why alloy steels appear to be more susceptible to the formation of flakes than carbon steel.

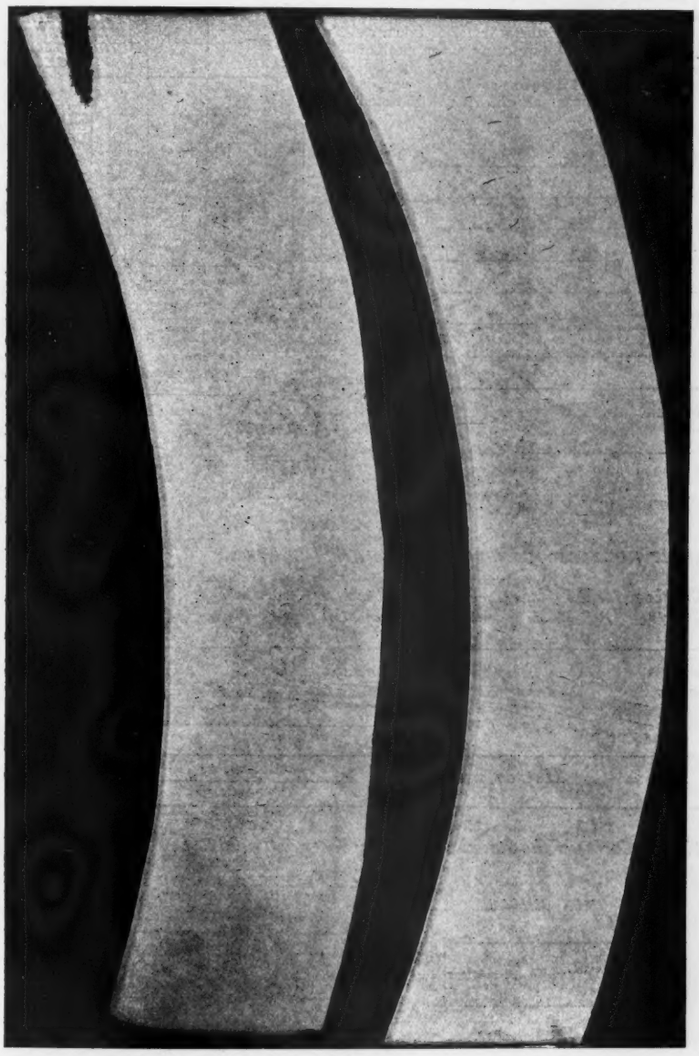


FIG. 10A.

FIG. 10A. Central Section, Parallel to the Side, of Ring 5A, Test Series 4. × 1.

Polished with Emery Paper.

FIG. 10B.

FIG. 10B. Central Section, Parallel to the Side, of Ring 6A, Test Series 4. × 1.

Treated with Iron-Dust on Magnet.

FIG. 12.

FIG. 13.

FIGS. 12 AND 13. Microstructure of Rolled Billet 110 × 110 mm. with Flakes. Etching 1 per cent. HNO_3 in Alcohol. × 1000.

Shattered Zones and Transverse Fissures in Rails.—Transverse fissures are cracks sometimes found in the head of steel rails after they have been in service. It is generally agreed that they are fatigue cracks starting from a nucleus somewhere in the central portion of the head and gradually spreading, finally reaching the surface, if the rail be not removed before this stage. On two points connected with this kind of failure opinions differ, viz.:—(1) On the nature of the nucleus of the fatigue crack; (2) on the predominant cause of the repeated stresses that is responsible for the fatigue fracture.

The author offers the following suggestions regarding shattered zones in rails and transverse fissures: Shattered zones in rails are probably cooling cracks, as suggested by Howard, and consequently identical with flakes. At first sight there seems, however, to be a difference in the law of their arrangement, flakes in rolled bars generally being longitudinal, whereas internal cracks in rails appear to be sometimes longitudinal, but more frequently transverse. If the author's view of cooling stresses being superimposed upon remaining deformation stresses, the resultant stresses determining the orientation of cracks formed be correct, it may be assumed that the difference in manner of reduction in the last pass between the rolls—open and closed grooves, respectively, different amount of spread—is the determining factor in this respect.

It has been convincingly demonstrated by Howard that the cold-rolling action of the wheels gives rise to accumulating internal compression at the tread, and to accumulating internal tension in the interior of the head up to a certain limit.

It seems self-evident that the presence of internal cracks in this region will greatly facilitate the beginning of fatigue fracture. As is well known, sharp cracks are very effective as notches in promoting fatigue failure. Instead of a hypothetical diffusive action from such cracks on the internal stresses, it would be expected that, in the lack of sufficient support from the interior of the head due to the shattered condition, the cold-rolling effect on the tread would proceed further and to a greater depth than would otherwise be the case. The increased volume of cold-worked and expanded metal in this zone would induce increased tension in the interior. Fatigue fracture would thus be hastened.

The conflicting opinions as to whether the prevention of shattered zones would do away with the development of transverse fissures in rails are based upon different interpretations of fractures examined. Apart from the difficulty of proving the absence of an original crack in a fatigue fracture of this kind, it seems, with the present knowledge at hand, that the matter could be easily put to an actual test. After some preliminary experiments, the proper cooling conditions for rails after rolling could be established, which would ensure freedom from internal cracks—as judged by the use of deep-etching or the magnetic iron-dust test—without causing softness or other undesirable reduction in strength. The behaviour of such rails in the track would then give the answer.

FOURTH REPORT OF THE STEAM-NOZZLES RESEARCH COMMITTEE.*

(*Concluded from page* 619.)

Test Results of Straight Elementary Nozzles.—The group of seven straight elementary nozzles, the tests of which were recorded in the third report (Curves 15 and 16), were each ¼ in. in diameter by 1¼ in. long. The Committee felt that useful information might be obtained if similar nozzles of different diameter were tested, so three separate and interchangeable nozzles were made up and mounted in the main tester as shown in Fig. 12 on page 652. Each of these nozzles was kept 1¼ in. long to correspond with the former group of seven ¼-in. nozzles, but their respective diameters were 1⅛ in., 1⅜ in., and 1⅝ in.

The tests taken on these nozzles gave the curves which are shown in Fig. 11. It will be noted that the accuracy of the previous tests has been maintained, but the largest nozzle passed too much steam for results to be obtained beyond a theoretical velocity of 1,300 ft. per second. There is a general similarity in shape and position between these single-nozzle curves and those of the group of ¼-in. nozzles referred to above. It will be found that a mean line through each of these bands shows, beyond 700 ft. per second, a slight increase in the value of the velocity coefficient as the diameter is decreased, though they are all definitely above the group of seven ¼-in. nozzles. It should be pointed out that all these tests were taken under winter conditions, when higher initial superheats prevailed, and comparison should therefore be made with Curve 16 in the Third Report. This diameter effect on the velocity coefficient should, however, not be stressed, as the tests of all three nozzles would fall within the band to the degree of accuracy possible.

These tests are useful in indicating the effect of a

* Presented at a meeting of the Institution of Mechanical Engineers on May 8, 1925. Abridged.

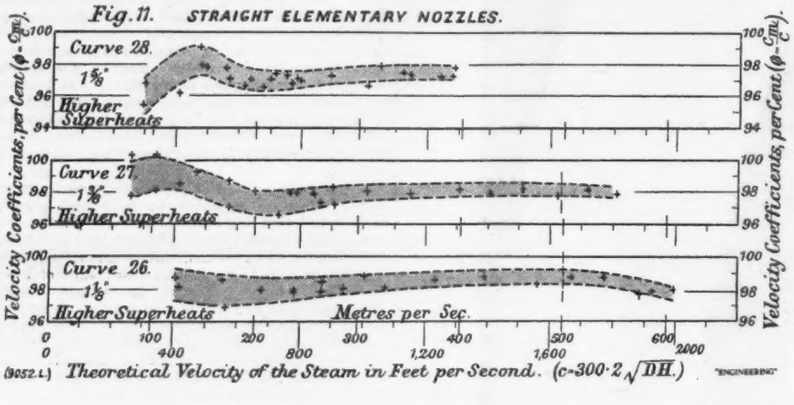
constant discharge nozzle. By cross plotting the actual discharge of these nozzles against theoretical velocity, the data given in Table XXIX, were obtained.

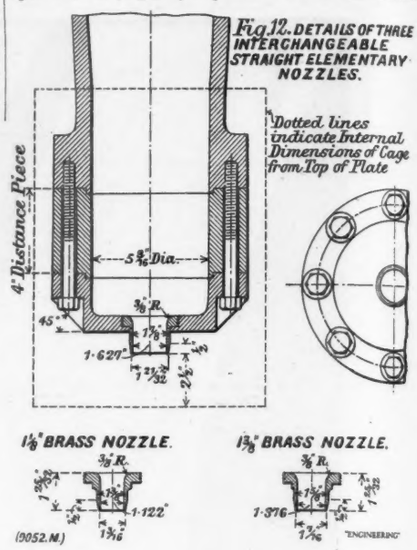
This Table enables three points to be determined for each selected discharge value, and by grouping all these curves together a composite curve (No. 29, Fig. 13) is obtained which indicates the shape to be expected for constant discharge conditions through single elementary nozzles of this nature. The curve has most of the characteristics discovered by the Committee, somewhat exaggerated. It exhibits the same degree of accuracy, the same gradual diminution in the

elementary nozzles of the Third Report had been arranged so that distance pieces of different lengths could be inserted. This may be seen in Fig. 12, which shows the same pipe adapted to take the single straight nozzles. The nozzle chosen for this investigation was the 1⅜ in., diameter single straight nozzle, which gave approximately the same cross-sectional area as the curved nozzles of the Committee. Tests, as taken at 6½ in. and 4½ in. and 1½ in. away from the top mesh of the cage plate, are shown plotted in Fig. 14. In each case the mean of Curve 27, taken at 2½ in. away, is added in dotted lines for comparison. It will be noted

that there is no appreciable difference to be expected between 6½ in. and 1½ in. away.

The Efflux Angles of the Steam.—The angle at which the steam leaves the nozzle, when blowing into the open air, was originally required to obtain the correct





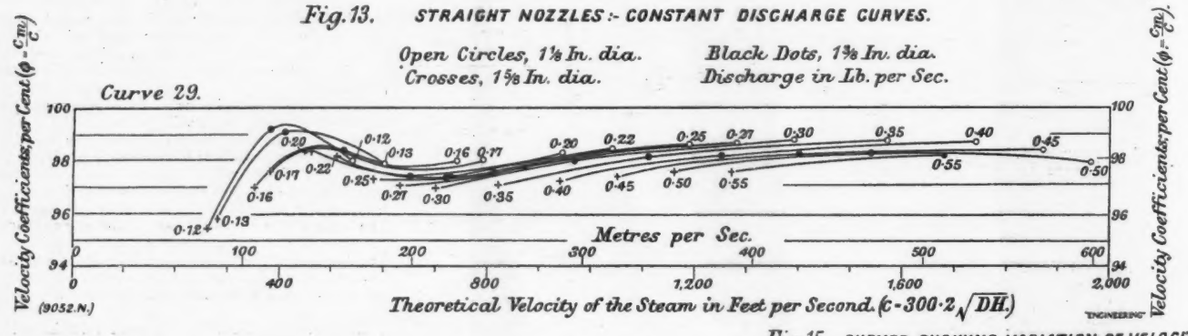


Fig. 13. STRAIGHT NOZZLES:- CONSTANT DISCHARGE CURVES.
Open Circles, 1⅛ In. dia.
Crosses, 1⅝ In. dia.
Black Dots, 1⅜ In. dia.
Discharge in Lb. per Sec.
Curve 29.
Metres per Sec.
Velocity Coefficients per Cent ($\phi = \frac{C_{act.}}{C}$).
(9052.N.)
Theoretical Velocity of the Steam in Feet per Second. ($c = 300 \cdot 2\sqrt{DH}$.)
"ENGINEERING"

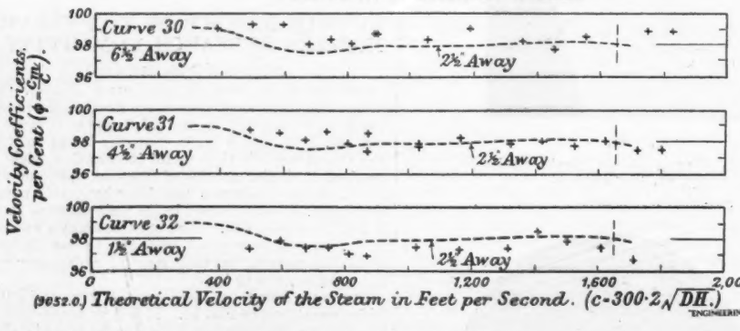
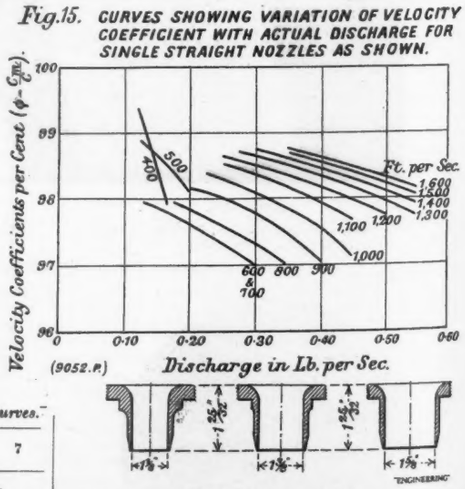


Fig. 14. CURVES SHOWING DISTANCE TESTS WITH 1⅜ INCH SINGLE ELEMENTARY STRAIGHT NOZZLE.
Curve 30
6½" Away
2½" Away
Curve 31
4½" Away
2½" Away
Curve 32
1½" Away
2½" Away
Velocity Coefficients per Cent ($\phi = \frac{C_{act.}}{C}$).
(9052.O.) Theoretical Velocity of the Steam in Feet per Second. ($c = 300 \cdot 2\sqrt{DH}$.)
"ENGINEERING"



velocity coefficient from the critical theoretical velocity to about 700 ft. per second, the much more rapid increase between 700 and 400 ft. per second and the turning over at very low velocities.

A further cross plot (of Fig. 13) is added in Fig. 15. This shows the variation of the velocity coefficient with the actual discharge as deduced from the mean of the curves. The three nozzles used for this analysis are not dimensionally similar, the only variation being in the diameter, as shown. Under these conditions the velocity coefficient, and therefore the efficiency of the nozzle, decreases with increasing diameter. It should, however, be noted that the velocity-coefficient scale in Fig. 15 is considerably enlarged, and that this effect lies within the degrees of accuracy of the original curves for the range covered by the sizes of these three nozzles.

A series of tests was taken to determine the effect, if any, of varying the distance between the mean exit-face of the nozzle and the top mesh of the cage plate. With this object in view, the nozzle pipe of the straight

TABLE XXIX.—*Data for "Constant Discharge" Curves.*

1	2	3	4	5	6	7
Actual Discharge in lb./sec	1⅛ in.		1⅜ in.		1½ in.	
	c	ϕ	c	ϕ	c	ϕ
0·12	260	95·4	380	99·2	540	98·0
0·13	280	95·8	410	99·15	600	97·9
0·16	350	97·0	520	98·4	740	98·0
0·17	380	97·6	545	98·2	790	98·05
0·20	460	98·4	650	97·45	940	98·3
0·22	510	98·2	720	97·4	1,040	98·5
0·25	580	97·35	810	97·6	1,190	98·65
0·27	630	97·1	870	97·8	1,280	98·7
0·30	700	97·0	965	98·0	1,390	98·8
0·35	820	97·1	1,110	98·15	1,570	98·8
0·40	940	97·3	1,250	98·2	1,740	98·7
0·45	1,050	97·45	1,400	98·25	1,870	98·4
0·50	1,160	97·6	1,540	98·3	1,965	97·9
0·55	1,270	97·6	1,680	98·2	—	—

setting of the nozzle-box in the main tester. Reference to work already carried out in this connection may be found in the Second and Third Reports. Additional results have been obtained during the period covered by the present Report. The method of tests was the same as that described in the Third Report. After the nominal 12 deg. impulse nozzles had been cut down to 0/1 throat ratio, both were subjected to efflux tests. In both cases, the angle of efflux of the steam close up to the exit face of the nozzle was found to remain practically constant, below the critical-pressure ratio, the value being 11½ deg. to a degree of accuracy of ± ½ deg. The thin-plate nozzle (Curve 20, Fig. 3) was originally set at 10½ deg., so that this deviation in the efflux angle is negligible, but the thick-plate nozzle was set at 6 deg., which was the mean value with a 3/1

throat deduced from the efflux tests recorded in the Second Report. In this case, the deviation of the centre of the jet was as much as $5\frac{1}{2}$ deg. when the 0/1 throat was tested (Curve 23, Fig. 5), and as the secant of $5\frac{1}{2}$ deg. is 1·0046, or very nearly $\frac{1}{209}$ greater than unity, the effect produced was outside the degree of accuracy of $\frac{1}{100}$ applied to the rest of the test. No correction for this has been made, however, in the results recorded in Table 23, though it is possible to argue that the velocity coefficient could be multiplied by 1·0046. The 12 deg. nominal impulse nozzles with chamfered exit have also been tested for both 3/1 and 0/1 throat. The former varied from 5 deg. to 7 deg., and the latter from 6 deg. to 8 deg. for pressure ratios between 0·9 and 0·55. All these results are shown in Fig. 16. Thin lines represent thin-plate nozzles, thick lines thick-plate nozzles, and dotted thick lines chamfered nozzles. Other salient curves from Fig. 8 of the Third Report have been added for comparison. These curves, in all cases, represent the efflux angle of the steam close up to the exit face of each nozzle. The chain-dot lines are the actual geometrical angles whose sines are $\frac{o}{g}$ and whose nominal values are 20 deg. and 12 deg., respectively. The curve of the built-up type of impulse nozzle has also been added to Fig. 16. It will be noted that the angle opens out some 4 deg. between pressure ratios of 0·8 and 0·55, and that the slope of the curve is as great as any other nozzle so far tested.

The Superheat Effect.—The degree of superheat, with the apparatus constituted as at present, is outside the control of the experimenters, but the fact that two types of nozzles have now been tested under summer and winter conditions enables a first determination to be made of a possible correction to be applied to the various curves obtained, so as to reduce them, for more direct comparison, to some common superheat values. The effects of superheat on the velocity coefficient appear to be two-fold. A higher degree of initial superheat, within the range of these experiments, tends to lower the value of this coefficient, whilst at the same time moving the curve bodily to the left, that is, towards a lower velocity. These effects were both shown in the Third Report, in the comparative tests taken on the seven elementary straight nozzles (Curves 15 and 16). They also show themselves, though not to the same marked degree, in the tests taken on the 12 deg. nominal thin-plate curved nozzles of this Report (Curves 19 and 19a). The mean lines through the bands of these four curves are reproduced in Fig. 17. The dotted curves represent what would appear to be the "shift" effect when referred to the lower superheat.

The average degree of superheat for any particular velocity may be obtained by plotting the initial superheat for each test against the theoretical velocity, and drawing average curves through the points. This has been done in Fig. 18 for the curved nozzles of Fig. 3, and for the straight nozzles shown in Fig. 13 (Second Report). It is only possible, at this stage, to make a provisional estimate of the "shift" of the higher superheat curve, in order to compare it more correctly with the lower superheat curve. An inspection of the mean velocity curves of Fig. 18B, drawn to a larger scale, goes to show that the curve for straight nozzles was moved about 100 ft. per second. This "shift" is shown in Fig. 18B by the dotted curve. It will be noted that the higher superheat of the curved nozzles reached four-fifths of that for the straight nozzles, so that, in the absence of further information, the "shift" of this curve has been taken at 80 ft. per second. If the values deduced from the test results are plotted for a difference of 10 deg. in the initial superheat, the curves shown in Fig. 19 are obtained. When the degree of accuracy of the original data is remembered, it would appear that these curves give the corrections in the table below to be applied for every 10 deg. of superheat within the present range of experiments.

It will be noted that these two curves are similar in shape, and that the 12-deg. curvature appears to modify the effect of superheat, although, without direct evidence on the point, it is likely that the 20-deg. curved nozzles would occupy some intermediate position. All the curves of the three Reports have now been examined in the light of this correction. Their initial superheats were plotted against theoretical velocity, a mean curve of superheat obtained, and comparison made with a "reference" curve of superheat. For this purpose a curve based on the lower superheat curve of the straight nozzles, Fig. 18B, was adopted as representing a suitable range for the

Velocities	400	600	800	1,000	1,200	1,400	1,600	1,800
12 deg. curved	0·4	0·20	0·15	0·125	0·10	0·075	0·03	0·00
Straight	—	0·35	0·20	0·19	0·17	0·15	0·125	0·10

Fig. 16.

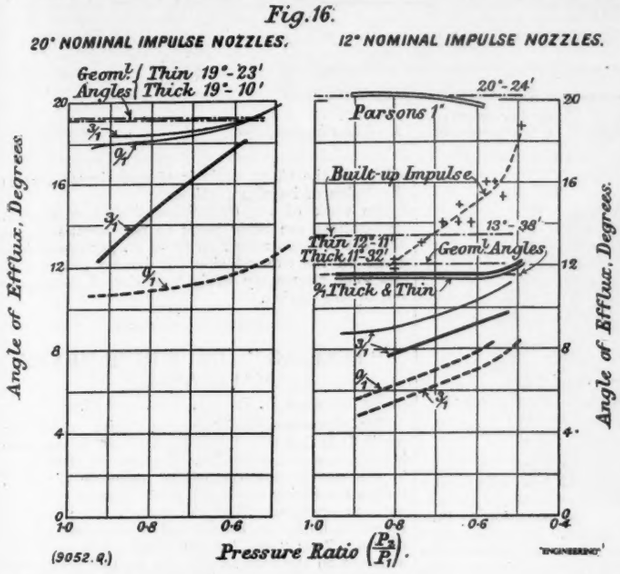


Fig. 17.

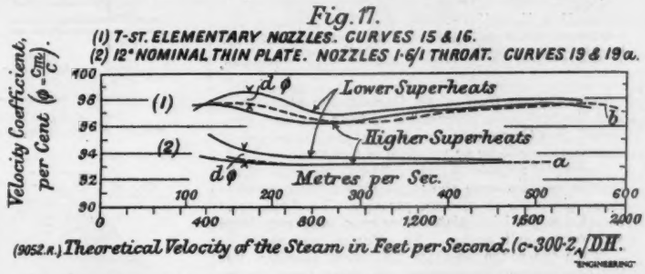

(1) T-ST. ELEMENTARY NOZZLES. CURVES 15 & 16.
(2) 12° NOMINAL THIN PLATE. NOZZLES 1·6/1 THROAT. CURVES 19 & 19a.
Velocity Coefficient, per Cent (φ = C/C')
Lower Superheats
Higher Superheats
Metres per Sec.
(9052.r.) Theoretical Velocity of the Steam in Feet per Second. (c=300·2√DH.)

Fig. 18A. 12° THIN PLATE IMPULSE NOZZLES. 1·6/1 THROAT. 4TH REPORT.

Fig. 18B. STRAIGHT ELEMENTARY NOZZLES. ¼ IN. DIA. 1¾ IN. LONG. 7 NOZZLES IN ACTION. 3RD REPORT.

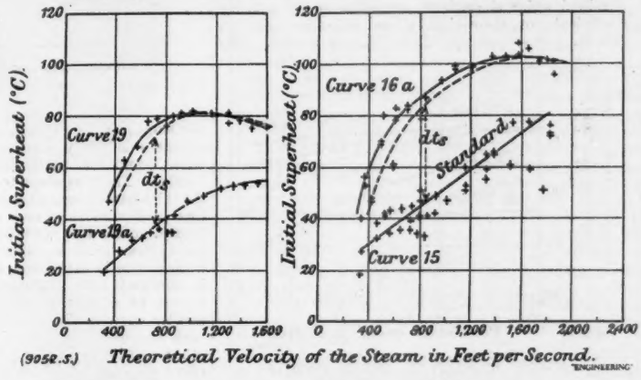


Fig. 19. INITIAL SUPERHEAT CORRECTION CURVES TO "LOW" SUPERHEATS.

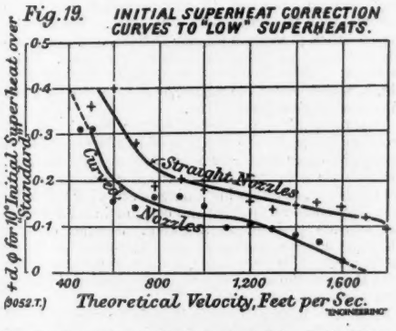
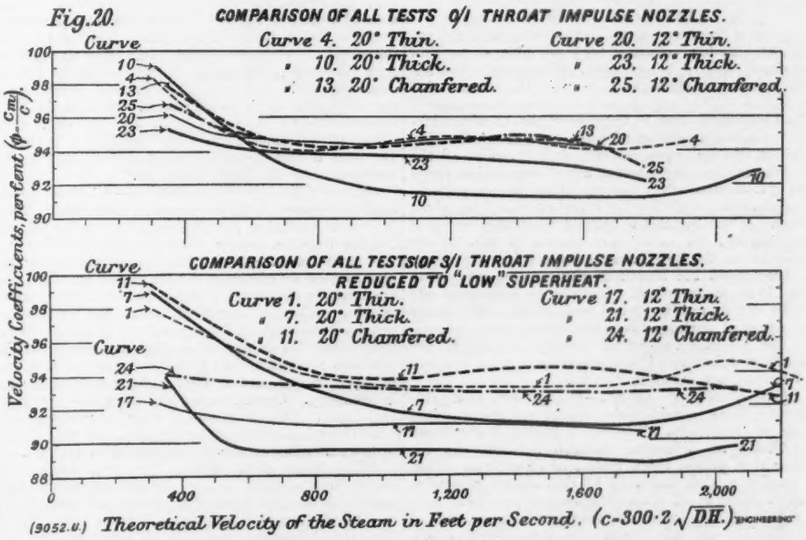


Fig. 20. COMPARISON OF ALL TESTS 0/1 THROAT IMPULSE NOZZLES.


Curve 4. 20° Thin.
" 10. 20° Thick.
" 13. 20° Chamfered.
Curve 20. 12° Thin.
" 23. 12° Thick.
" 25. 12° Chamfered.
Velocity Coefficients, per Cent (φ = C/C')
COMPARISON OF ALL TESTS OF 3/1 THROAT IMPULSE NOZZLES. REDUCED TO "LOW" SUPERHEAT.
Curve 1. 20° Thin.
" 7. 20° Thick.
" 11. 20° Chamfered.
Curve 17. 12° Thin.
" 24. 12° Chamfered.
(9052.u.) Theoretical Velocity of the Steam in Feet per Second. (c=300·2√DH.)

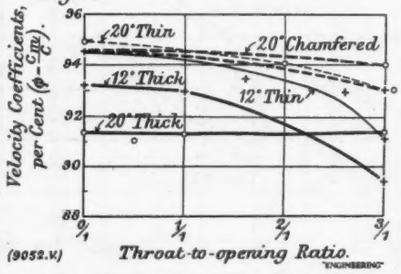
tester. This was taken as a straight line drawn from 30 deg. C. of initial superheat at a velocity of 400 ft. per second to 80 deg. C. of initial superheat at a velocity of 1,800 ft. per second. The result of this examination showed that the mean line of the corrected results falls within the band of the original curves in the great majority of cases, the only exceptions being the 12-deg. nominal thin-plate nozzles of this Report, which had exceptionally high superheats at the lowest velocities. In this nozzle the corrections are as follows :—

Velocity..	400	600	800	1,200
3/1 throat (Curve 17)..	1·2	0·92	0·68	0·55 ϕ up
2·6/1 throat (Curve 18)	1·75	1·16	0·94	0·7 ϕ up.
1·6/1 throat (Curve 19a)	Standard			
0/1 throat (Curve 20)..	1·12	0·8	0·65	0·29 ϕ up,

Review of the Work of the Committee to Date.—Now that the first main programme of tests has been completed, the Committee feel that a general review of their work would be appropriate at this stage.

Convergent Impulse Nozzles.—The proportions of the impulse nozzles were chosen as representing extreme cases met with in modern practice. Very thin and very thick partition plates were used, and very large and very small angles. No attempt was made to improve the rough finish of the steam passages, but the nozzles were successively cut down from a very long throat to no throat at all. A wider range of steam velocities was found possible than with any previous published tests, and curves were consistently obtained which showed the deviation of the velocity coefficient for theoretical steam velocities between 300 ft. per second and 2,000 ft. per second. The

Fig. 21.



CROSSES. 12° NOZZLES. CIRCLES 20° NOZZLES.
1,200 FT. PER SEC. THEORETICAL VELOCITY.

accuracy of these curves was of the order of $\pm$ 1·0 per cent. at very low velocities, $\pm \frac{1}{2}$ per cent. at medium velocities, and $\pm \frac{1}{4}$ per cent. at higher velocities. Care was taken throughout to maintain comparative conditions. The only deviations were the degree of initial superheat, and, in the case of the 12 deg. thick-plate nozzles, a setting of 4 in. away from the top mesh of the cage plate instead of 2½ in. as in all the other tests, but experiments are shown which prove that this distance effect does not affect the comparison. A method of correction for superheat has been given above. If this method is applied to all the curves of the research, the mean lines shown in Fig. 20 are obtained for the two extreme cases when the throat is three times the length of the opening and when there is no throat at all. In order to summarise the results still more, Fig. 21 has been added. This shows the effect of cutting down the throat from between 3/1 and 0/1 at a theoretical velocity of 1,200 ft. per second, and includes intermediate points for 2/1 and 1/1 throats not shown in Fig. 20.

Effect of Throat Length.—It appears that this depends, to a considerable extent, on the nominal angle of the nozzle. Whereas a 20-deg. angle shows practically no difference between 2/1 and 0/1 for either thin plates, thick plates, or chamfered plates, a smaller angled nozzle of 12 deg. shows successive improvement in all cases between 3/1 and 1/1.

Effect of Thickness of Partition Plates and of Chamfering.—In all cases, for any given angle, unchamfered thick partition plates gave worse results than thin plates. If, however, a suitable chamfer is worked on the back of each partition plate, so as to eliminate the flat surface in the exit plane of the nozzle, then neither the length of the throat nor the angle of the nozzle makes any appreciable difference over the usual working range of impulse nozzles. Moreover, in all cases the result of chamfering the thick partition plates lifts the value of the velocity coefficient (and therefore of the efficiency) up to, or above, the corresponding values for thin plates. In other words, a chamfered thick partition plate gives quite as good results as a thin plate irrespective of the angle of the nozzle.

Effect of Angle of the Nozzle on Efficiency.—The angle effect is, to some extent, inter-connected with the length of parallel throat. The longer the throat the more definitely worse are the 12 deg. angle nozzles when compared with their corresponding 20 deg. nozzles. There appears to be one exception to this, the thick-plate unchamfered nozzles. The throat effect here predominates to such an extent that, whereas the 20 deg. nozzle does not alter as the throat is cut down, the 12 deg. nozzle shows a steady improvement. The consequence is that below a 2/1 throat, a better result is obtained with the smaller angle. This anomaly is not of serious practical importance, since both nozzles showed themselves to be, in general, worse with the unchamfered thick plates than under any other conditions of test. There is, however, another effect of angle which should be noted. All the 20 deg. angle nozzles (as well as the reaction nozzles) showed a more or less pronounced rise below a velocity of about 700 ft. per second as this velocity was further decreased to 300 ft. per second. This effect was present, to a very much less degree, in the case of the 12 deg. angle nozzles. The curves, in general, were nearly flat throughout their tested length. Here, again, there appears to be one exception, the 12 deg. angle unchamfered thick-plate nozzle with a 3/1 throat. But even in this case the upward bend is considerably modified with the shorter throats.

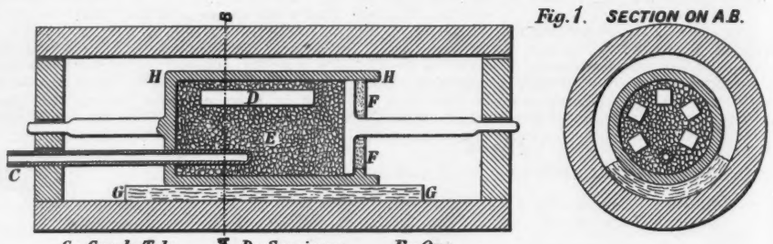
General Efficiency Considerations.—All these effects may be summed up in the following statement. There is a wide variation permissible in the design of converging impulse nozzles when maximum efficiency is the chief consideration. Thick partition plates can give as good an efficiency as thin plates, provided they are carefully chamfered at exit. Below a 2/1 throat-to-opening ratio, the length of throat has little effect, provided the angle of the nozzle is 20 deg., but throats longer than 1/1 should be avoided with smaller angles. Between 1/1 and 0/1 the angle of the nozzle may vary between 20 deg. and 12 deg. without appreciable loss in efficiency. Conditions both of entry and of exit are important. The steam should enter the nozzle passage with the minimum amount of shock, and flat surfaces in the exit plane of the nozzle should be avoided.

Efflux Angles of the Steam.—The efflux angle of the steam from a nozzle is very simply measured by the apparatus devised by the Committee and described in the Third Report. In general, it was found (below the critical-pressure ratio) to be more nearly equal to the angle whose sine was $\frac{o}{p}$, where o is the throat opening and p the pitch of the nozzle, than to the nominal angle of the nozzle whose sine was $\frac{o}{q}$. It was found, in general, that shortening the throat tended to flatten any deviations there might have been over different pressure ratios down to the critical value, but this can only legitimately be applied to the shape of nozzle tested by the Committee. The built-in type of impulse nozzle, for instance, showed considerable variation in angle with practically no throat. The Committee suggest that most useful information can be obtained on this point without difficulty or great expense, if a sample nozzle-box of any particular type is made up and tested for efflux, as the efflux angle is of such importance in the design of impulse turbines.*

The work of the Committee is still continuing. Preparations are being made to test nozzles over a different pressure range, up to 60 lb. per square inch gauge on the exhaust side. It is also proposed to test some elementary straight nozzles of rectangular and square section.

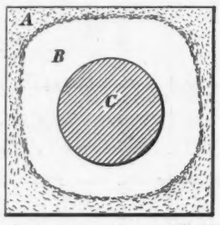
"PEELING" IN WHITE-HEART MALLEABLE.

Fig. 1. SECTION ON A.B.



C = Couple Tube. D = Specimen. E = Ore.
F = Fireclay Lining. G = Asbestos Pad. H = Experimental Pot.

Fig. 2.



A = Oxide Penetration. B = Ferrite.
C = Pearlite and Ferrite.

"PEELING" IN WHITE-HEART MALLEABLE.†

By DOUGLAS H. INGALL, M.Sc., and H. FIELD.

THE phenomenon of "peeling" with which this paper deals is a defect well known both to malleable ironfounders and machinists, being met with frequently in the manufacture and use of malleable cast iron. Castings suffering from this defect present a normal outward appearance, but the fracture after breaking reveals an inner core, surrounded by one or more layers of "skin" or "peel," these layers being so loosely attached to the core and to one another that either they become detached in the breaking or can be removed by a few blows with a hammer. The remaining core then presents a smooth surface, and has generally the same contour as the original specimen. Fractures of "peeled" malleable iron are illustrated in Fig. 3, which shows the separated peel in one part and the remaining core at another.

The mechanical properties of the metal are not greatly affected by the presence of this internal defect, except in cases where it may be very pronounced. The trouble with "peeled" castings arises when they are machined, as either in planing or screwing the entire skin may come away from the core, or in milder cases the threads peel off as a string. Smaller castings which are not machined are often water-barrelled before plating, and this prolonged process sometimes wears right through the outer skin at one place and the whole then peels off.

From the known irregularity of the occurrence of "peeling" in works practice, and in view of the divergent and sometimes conflicting opinions expressed on the phenomenon, it was obvious, to the authors, that any investigations would have to cover a wide field. The possible controlling influences appeared to be capable of classification, under the following main headings: (1) chemical composition of the cast iron; (2) structure of the cast iron; (3) temperature of annealing; (4) time of annealing; (5) rate of heating to annealing temperature; (6) nature of the annealing ore. The experimental work which was undertaken was therefore developed to investigate the above-mentioned influences under known conditions, but at the same time every endeavour was made to make the known conditions such that they could be directly comparable with works practice.

Annealing Furnace.—Fig. 1 shows a diagrammatic sketch of sections through the annealing furnace, which was a horizontal electric resistance tube furnace, the silica tube being 4¾ in. inside diameter and 18 in. long. The tube was closed at each end with firebrick non-heated plugs 2 in. thick.

Annealing Cans.—These were made of ordinary white cast iron of the kind known in the trade as "can metal." Each can was of cylindrical form, having an inside diameter of 4 in. and a length of 6 in. As shown in Fig. 1, a lug was cast on one end of each box and also on the lid to help to support the box in the furnace. A hole was also cast at the end of each box, at a radius to which the specimens were inserted, to take a nickel-chromium tube containing the thermocouple. This tube was wedged into position with asbestos paper, and

* See "The Proportioning of Impulse Blades and Nozzles," by Professor G. Gerald Stoney, D.Sc. F.R.S. ENGINEERING, October 3, 1924, page 473.

† Paper read before the Iron and Steel Institute, London, on May 8, 1925. Abridged.

the scaling of the iron with each experiment was quite sufficient to seal it in. After the lid was placed in position, it was luted up with fireclay.

Specimens.—All the specimens were cast in green-sand under works conditions to dimensions 3¼ in. by ¾ in. square.

Annealing Ore.—This was taken from the stock in use at the malleable annealing ovens, and consisted of four parts of used ore and one part of new red hematite ore, the whole being of 70 Kibble mesh.

Temperature Measurements.—These were made by means of a platinum, platinum-rhodium couple inserted into the couple tube. As no continuous recording instruments were available, the temperature records were made from frequent readings. It was found by observation that the fluctuations (due to variations in the electric supply) did not amount to more than plus or minus 12 deg. C., which was well within works practice.

Rate of Heating.—To conform to works practice, the rate of heating, unless otherwise specified, was in each case such that about 30 hours were required to reach the required temperature and about 30 hours were taken to cool off.

Testing.—To test for "peeling," the specimens were clamped firmly in a vice for 1 in. of their length, and then gradually bent over with blows from a hammer until fracture occurred. The fractures were then examined for the separation of peel from core.

Experiment A.—To Investigate Chemical Composition.—Specimens giving a wide range of composition were packed in a box and annealed for four days (96 hours) at a temperature of 950 deg. C. All the samples were fully annealed, without any signs of hardness. From the analyses it was seen that peeling was obtained with metal which exhibited no particular feature with regard to any one of its constituents. The specimen which had peeled most had quite an average analysis. It was therefore decided to take sulphur prints of the specimens (longitudinal sections) and to examine them microscopically; at the same time, in view of the possible effect of "original structure," it was decided to investigate the micro-structure of specimens in the "as cast" condition. In the as-cast condition all specimens showed the normal structure of white iron without any particular feature, as shown in Fig. 4, which is characteristic of all the samples. Longitudinal sulphur prints of the specimens of malleable showed that the peel, where it occurred, was comparatively free from sulphur; but sulphur segregation was found at the boundary between peel and core in patches in several specimens.

It was found that, broadly speaking, all the specimens of malleable exhibited one general type of structure. As this type of structure was also found in all subsequent specimens which were microscopically investigated, and as it revealed the nature of the "peel," it was thought that a somewhat detailed description of it would not be out of place.

A diagrammatic sketch of the structure is given in Fig. 2, on page 654, which represents a cross-section of a specimen. It is seen that the structure resolves itself into three main zones which, taken in order from the outside of the specimen to the centre, are composed as follows:—

Zone 1.—Highly oxidised metal containing free globules of oxide.

Zone 2.—Ferrite becoming more and more oxidised towards the border of Zone 1.

Zone 3.—Pearlite and ferrite.

The three zones are clearly seen in Fig. 5.

FIG. 3.

FIG. 4. × 50.

Cast Structure of Specimen 2.

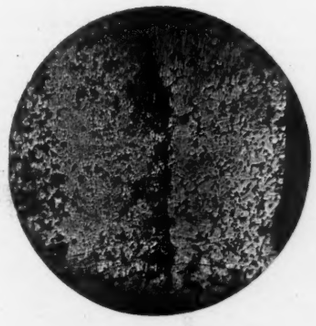


FIG. 5. × 50.

FIG. 6. × 25.

NOTE.—Figs. 4 to 6 have been Slightly Reduced.

Zone 1.—This is the zone which forms the "peel," in a specimen. The extent and amount of peel is determined by the degree of penetration of this zone. At the boundary of this zone with the ferrite (Zone 2) it was generally found that there was an accumulation of inclusion which was more or less continuous, and the boundary formed the cleavage plane along which the "peel" (Zone 1) separated from the "core" (Zones 2 and 3). Sometimes it was found that Zone 1 contained two or more of these accumulation boundaries, in which case the specimen would exhibit a number of "peels" corresponding with the number of boundaries. The cross-sectional specimen in Fig. 3 shows one such case. Fracture taking place along two such boundaries is shown in Fig. 6, which is taken from a longitudinal micro-specimen. Freedom from peeling was found to be consistent with either absence of Zone 1 or its presence to a very limited and irregular extent.

Zone 2.—This zone calls for very little comment. Its oxidised condition towards the boundary of Zone 1 is shown by the staining of the etching reagent in Fig. 5. As would be expected, the grain-size of the ferrite was larger the higher the temperature of annealing.

Zone 3.—The extent of the whole zone and the relative proportion of pearlite in it varied, according to the decarburisation. Generally, as might be inferred, the amount of carbon varied from a minimum at the border of Zone 2 to a maximum at the centre of the specimen. In the cases of incomplete annealing, free cementite was found in the central portions.

The relative widths and extents of the three zones were found to vary considerably, according to annealing conditions.

Influence of Temperature of Annealing.—Experiment B.—Four days (96 hours) at 910 deg. C. The results with regard to peeling showed that the lower temperature obviously, did not promote the production of peel, but, on the other hand, the specimens were not thoroughly annealed. The micro-structures revealed the general type of structure in which Zone 1 was practically absent or irregular, and in Zone 3 there were areas containing more or less free cementite.

Experiment C.—Four days (96 hours) at 1,010 deg. C. The temperature of this experiment is probably above the maximum aimed at in good works practice, where 1,000 deg. C. is generally looked upon as too high. The results indicate that a high temperature tends to suppress rather than accelerate the production of peel. All the specimens were quite soft, and the micro-structures revealed the general structure, with usually a rather indefinite Zone 1, a fairly wide Zone 2, and a relatively small Zone 3, with low average carbon content, containing in some cases small amounts of graphitic carbon.

Influence of Time of Annealing.—As most peeling had been obtained at 950 deg. C. it was determined to prolong the time of annealing at that temperature.

Experiment D.—Six days (144 hours) at 950 deg. C. The results showed at once that, under suitable conditions, the growth of peel progresses with time.

Experiment E.—As the results were so much more pronounced than anything obtained previously, it was thought desirable to repeat the conditions. This was done in Experiment E, which, with small variations, entirely confirmed the results of Experiment D. The microstructures were of the general type, giving on an average a comparatively large Zone 1 and a small Zone 3.

The authors were yet without evidence as to the influence, or influences, which start the peeling phenomenon. As, in the last two experiments, the extent of the peel reached in some cases to nearly half-way between the outside and centre of the specimens, it was resolved to make analyses with regard to silicon and sulphur on sections of some of the specimens, obtained by milling off successively one-third of the whole specimen all round.

The figures obtained confirm the results of the sulphur prints to the extent of revealing a minimum sulphur content in the peel.

Similar analyses on reduced sections of the bars in the hard state showed that the silicon and sulphur in the original metal are equally distributed within macroscopic limits, and without segregation.

Experiments with Regard to the Sulphur Content of the Metal.—From a consideration of the results obtained from specimens containing varying amounts of sulphur, it would appear that both high and low sulphur contents are deterrents towards peeling which may most easily be produced within a range of sulphur content from approximately 0·2 per cent. to 0·4 per cent. The results would also indicate that the higher the silicon content, the greater is the tendency for the production of peel.

Experiment for Investigating Rate of Heating.—For this experiment, an abnormal rate of heating was employed to give an extreme result. A temperature of 950 deg. C. was reached in seven hours and maintained for six days (144 hours). Results showed that it was obvious that rapid heating was an important factor towards the production of peel.

Experiment to determine whether the Phenomenon of Peeling begins with the Annealing Effect or is Developed Later.—Rapid heating in seven hours to 950 deg. C. and maintained at that temperature for two days (48 hours). The results showed that the phenomenon of peeling, when present, commences with the annealing effect. The microstructures were consistent with the general type of structure, according to the conditions and showed free cementite in Zone 3.

Experiments under works conditions confirm the conclusion that increased rate of heating promotes the development of peel, but that a high annealing temperature retards its growth.

The formation of peel is the result of oxidation of the metal. There would appear to be an approximate critical temperature between 900 deg. C. and 940 deg. C. above which this oxidation effect may commence. As soon as oxidation begins, the growth of the oxide layer would appear to depend on the result of a race between rate of oxidation and rate of carbon supply by diffusion from the interior. It is for this reason that rapid heating promotes rapid peel growth, as the cementite has not time to dissolve and diffuse at a rate necessary to counteract the penetrating oxidation. The retarding effect of high temperatures will be seen to be due to the more rapid solution and diffusion of the cementite.

The authors have no explanation to offer with regard to the rôle played by the sulphur content of the material-

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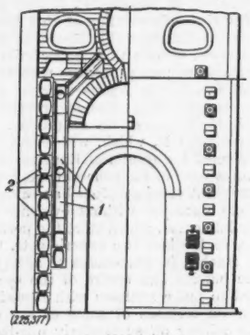
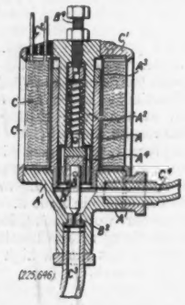
GAS ENGINES, PRODUCERS, HOLDERS, &c.

225,377. H. J. Toogood, Elland, and Robert Dempster and Sons, Limited, Elland. Horizontal Retorts. (5 *Figs.*) November 28, 1923.—The invention relates to the heating of horizontal retorts for gas production. According to the invention, the waste heat and secondary air are carried by machine-made tubes 1, 2. These tubes are arranged in two contacting vertical tiers or planes. The tubes 1 carrying the secondary air



are arranged with their axes vertical, and the tubes 2 carrying the waste heat are for facility of cleaning arranged with their axes horizontal, and all joints in the one tier are staggered in relation to the joints in the other tier, so that possible leakage is prevented to the maximum extent, and should a fire crack develop in one tube it is covered by the solid wall in the adjacent tube. —(*Sealed.*)

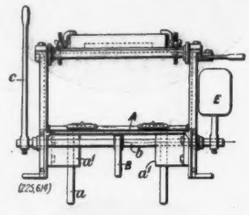
225,646. North British Diesel Engine Works (1922), Limited, Whiteinch, Glasgow, and N. Young, Whiteinch, Glasgow. Obtaining Indicator Diagrams. (4 *Figs.*) September 22, 1923.—The invention has for its object to provide apparatus for indicating and recording pressures in the cylinders of internal-combustion engines. The improved apparatus, which is broadly applicable in any case where fluctuating pressure in conjunction with rotatory or reciprocating movement is present, is of the type which comprises essentially a means of connection between the cylinder and a pressure-indicating or recording device, a valve controlling that connection and means for operating that valve from the crankshaft or rotatory element



of the engine in such a way that it is opened briefly during the pressure cycle of the engine at a determinate and adjustable point. According to the example illustrated, there is provided a brass cylinder A which is screwed into a base portion A^1. Screwed into the cylinder A is an adjustable core A^2 with a central aperture therein and which is fixed in position by a screwed ring A^3, thereby forming an airtight chamber in conjunction with the base portion. An endwise movable plunger A^4 is inserted in the cylinder A below the core A^2 and carries a needle valve B, which is magnetically insulated from the plunger A^4 by a brass bush B^1 and which is adapted to engage a valve seat B^2 in the base portion A^1. The valve B is held in contact with the valve seat B^2 by means of a compression spring inserted in the aperture of the core A^2 and bearing on the plunger A^4. The pressure of this spring may be adjusted by means of a set-screw B^4. Externally surrounding the brass cylinder A is a magnet-coil C, and the whole mechanism is enclosed in a cover C^1 which is secured to the base portion A^1. The ends C^2 of the magnet-coil pass through the cover C^1. Connection to the source of pressure is made by means of a pipe C^3 extending from the base portion, and connection to a recording device is made by means of a pipe C^4 extending from the base portion from a point above the valve seat. The operation of the valve mechanism described is controlled by an electrical contact-maker. In operation, the contact-maker makes one revolution for each pressure cycle of the engine, thus completing the electric circuit of the magnet-coil C once in each pressure cycle. The contact elements may be so set that the electrical circuit is completed at any desired point in the pressure cycle. On completion of the electrical circuit a current passes through the magnet-coil C, thus creating a powerful magnetic pull on the plunger A^4, which rises against the action of the spring, opens the valve B and allows the pressure at that instant of the cycle to be recorded on the gauge connected to the pipe C^4. When the electrical circuit is broken, the valve is immediately reseated by the action of the spring. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

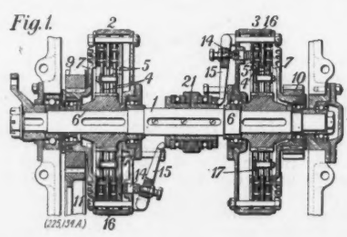
225,614. H. Howle, Ripponden, near Halifax. Sand Moulding Machines. (5 *Figs.*) September 4, 1923.—The invention relates to sand-moulding machines for foundry purposes and to that type of machine in which a turn-over table which carries the pattern plate and flask is used in conjunction with a counter-balanced lifting and lowering plate, which is raised and lowered by a hand lever. According to the invention,



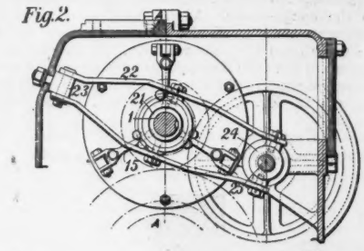
the lifting and lowering plate A is provided at or near two diagonal corners with two guide rods *a* which pass through guide brackets a^1, and extending across the machine between the brackets a^1 is a shaft *b* carrying an eccentric or cam B disposed midway between the guide brackets, the shaft *b* being provided with a hand lever *c* and counter-balance weight E. (*Sealed.*)

MOTOR ROAD VEHICLES.

225,134. Barford and Perkins, Limited, Peterborough, and G. W. L. Hood, Peterborough. Change Speed Gears. (4 *Figs.*) May 23, 1924.—The invention relates to those change speed gears in which either of two alternative sets of gearing are each adapted to be brought into action by means of a friction clutch, the clutches being engaged by mechanism embodying a single spring or set of springs which holds one clutch in engagement and leaves the other free, the mechanism being arranged so that in either position the engine tends to keep the engaged clutch in the engaged position. The invention comprises a change speed gear of the character described in which the spring is mounted so as to exert a turning moment on a shaft in either of its extreme positions to engage one or other of the clutches through a



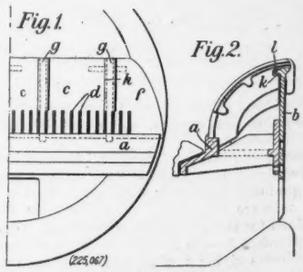
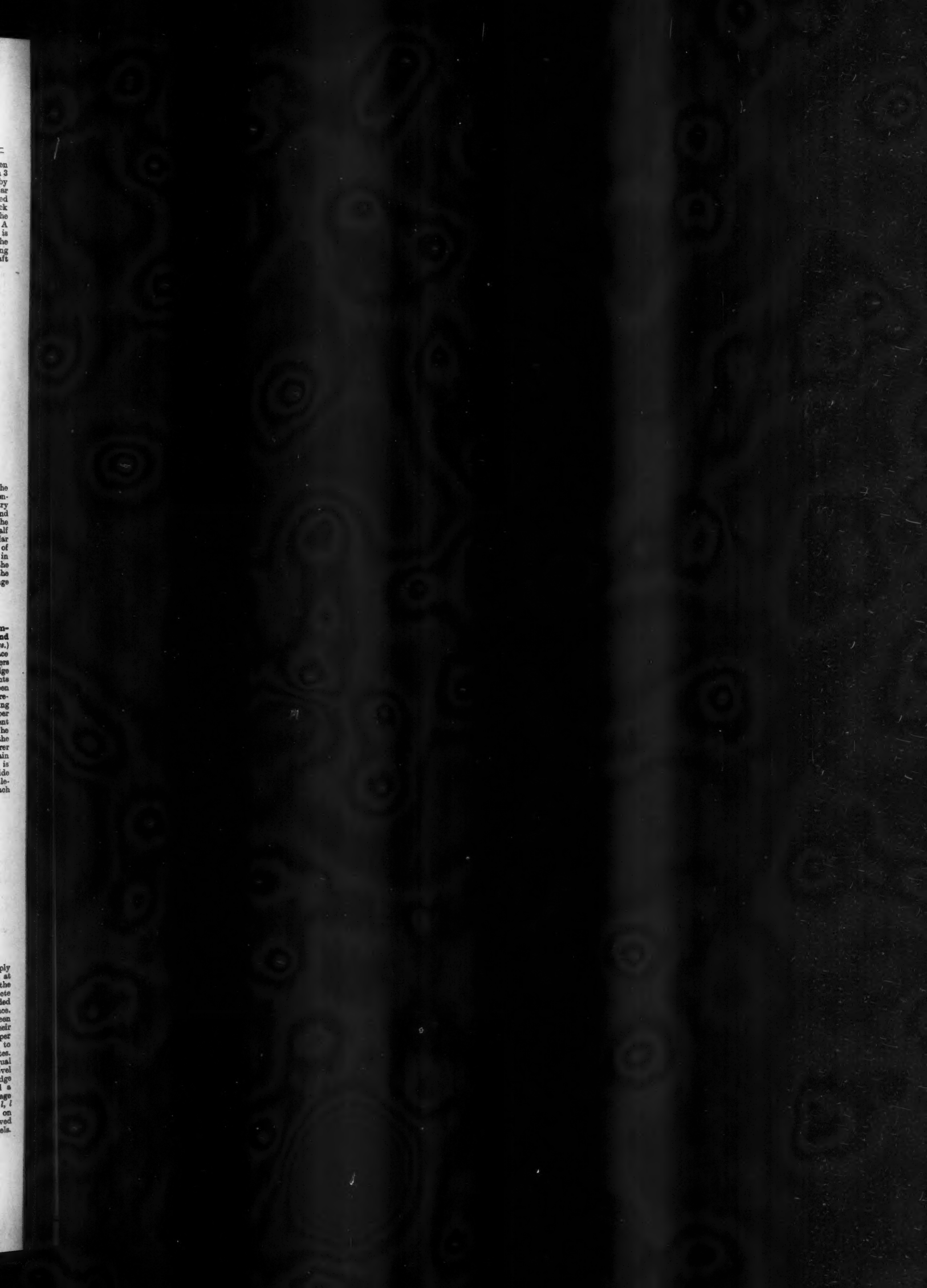
screw and nut and levers controlled by the shaft. Power is transmitted to a shaft 1 on which is mounted a pair of friction clutches 2 and 3 each comprising inner plates 4 keyed to a member 6 keyed to the shaft 1 and outer plates 5 secured to the clutch housing 7. The housings 7 are carried on bearings on the shaft 1, gear wheels 9 and 10 being secured respectively to the housings of clutches 2 and 3. The gears 9 and 10 both transmit their rotation to a shaft in the main gear box, the gear 9 directly through a gear 11, and the gear 10 through an idler so that the direction of rotation is opposite to that caused by gear 9. The clutches are engaged by means of plungers 14 operated by pivoted levers 15. In the free position, the outer plates 5 are held apart by springs 16 and the inner plates 4 by springs 17. The levers 15 are controlled by a sliding collar 21. When this collar is moved to the left, clutch 2 is engaged and clutch 3 disengaged. When moved to the right, clutch 2 is disengaged and clutch 3 engaged. In the first case the drive is transmitted by gear 9 and in the second by gear 10. The sliding collar 21 is operated by a pair of levers 22 pivoted to a fixed bracket 23 and moved by a nut 24 working on a quick pitch screw cut on a shaft 25. Keyed to one end of the shaft 25 is a disc 26 carrying a crank-pin 27. A plunger rod 28 is pivoted to the crank-pin 27 and is guided in a sleeve 29 pivoted to a fixed point on the gear box. The plunger rod 28 is pressed by a spring 31 and therefore exerts a turning moment on the shaft



25, thus tending to move the nut and therefore the collar 21. One of the clutches will, therefore, be engaged, the spring 31 thus providing the necessary pressure. The pitch of the thread on the shaft 25 and the proportions of the levers and other parts of the mechanism are designed so that approximately a half turn of the shaft 25 is sufficient to move the collar 21 from one extreme position to the other. In either of the extreme positions the spring will tend to hold in engagement the particular clutch engaged and the turning moment on the shaft 25 will be practically at the maximum value. The shaft 25 may be rotated to change the gears by a handle. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

225,067. The "Parabola" Furnace Bridge Company, Limited, London, L. Le Sueur, London, and F. S. Jordan, London. Furnace Firebridges. (7 *Figs.*) December 4, 1923.—The invention relates to furnace firebridges of the type wherein curved retaining members are adapted to interlock with the back bearer and bridge plate and which are spaced at intervals between segments or groups of firebars which are fitted tightly between each pair of the retaining members. In a furnace firebridge constructed according to the invention the spacing bars are formed with flanges or wings on their upper edges which are adapted to overlap the edges of adjacent segments or adjacent segment and wing plates. The segments and wing plates may be recessed to receive the flanges or wings of the spacing bars. *a* is the back bearer which at its front supports the rear ends of the main firebars (not shown) and *b* is the bridge plate which is supported by the back bearer *a* at or along the rear side of same. The firebridge segments consist of saddle-shaped metal sections *c* vertically disposed. Each



segment is formed with air passages *d* to allow a supply of air to pass through to the fire and with passages at the rear for the purpose of allowing air to mix with the partially combusted gases and bring about complete combustion. *f* is a wing plate, one of which is provided at each end of the bridge to abut against the furnace. *g*, *g* are spacing bars, these bars being interposed between adjacent segments and between the wing plates and their adjacent segments. Each bar *g* is formed at its upper edge with two flanges or wings *h* which are adapted to fit in recesses formed in the segments and wing plates. The depth of the flanges and recesses should be equal so that the segments, wing plates and bars are level when placed in position on the back bearer and bridge plates. At the rear of each segment *c* is formed a channel *k*, these channels being adapted to engage locking stops *l*, *l* on the bridge plate *b*. The stops *l*, *l* are so positioned that the segments can be placed on the back bearer *a* and bridge plate *b* and be then moved lengthwise of the bridge for the stops to enter the channels. (*Sealed.*)